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ADVANCING IMPLEMENTATION OF DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION PROGRAMMES

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA NUCLEAR ENERGY SERIES No. NW-T-1.10

ADVANCING IMPLEMENTATION OF DECOMMISSIONING AND ENVIRONMENTAL REMEDIATION PROGRAMMES

CIDER PROJECT: BASELINE REPORT

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FOREWORD

One of the IAEA's statutory objectives is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Article III.A.6 of the IAEA Statute, the safety standards establish "standards of safety for protection of health and minimization of danger to life and property". The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style, and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist R&D on, and application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

Despite the progress achieved in some countries since the 1990s, much remains to be done in terms of addressing the legacies from the early development of nuclear energy and atomic weapons, including the dismantling of disused research and fuel cycle facilities, research reactors and power plants, and the remediation of sites affected by past uranium mining and processing operations or as a result of nuclear testing or accidents. Long term solutions still need to be found for the management of the resulting waste, including development of disposal facilities that meet public acceptance and safety requirements. Some States are moving forward in dealing with these legacies, and accordingly have built up appropriate technical resources and expertise, but many national programmes still face very significant challenges.

Dealing with the legacies from past nuclear and non-nuclear activities is a global concern. Principles of social justice and intergenerational equity provide fundamental reasons why governments should undertake early decommissioning of disused nuclear facilities and remediation of radioactively contaminated sites. The factors constraining progress in addressing past legacies were considered at Side Events to the IAEA General Conferences in 2010, 2011 and 2012. The discussions at these events pointed to the importance of early implementation of decommissioning and environmental remediation (D&ER) programmes in order to protect people and the environment from the undesirable effects of ionizing radiation and from other hazards associated with these sites. It was concluded that there is an urgent need to better understand the global status and to analyse, and report on, the barriers impeding the implementation of D&ER programmes, with the aim of outlining actions that may improve the current situation. In addition, understanding the barriers hindering progress at D&ER legacy sites can provide information for new and existing facilities so that similar issues can be avoided.

In March 2013, the Constraints to Implementing Decommissioning and Environmental Remediation (CIDER) project was launched by the IAEA with the broad aim of contributing to improve current levels of performance on D&ER programmes through promoting greater cooperation among IAEA Member States and relevant international organizations.

This collaboration and analysis conducted through the CIDER project was used to develop this publication, which provides a detailed analysis of the constraints that have delayed implementation of D&ER programmes in many Member States and presents various strategies and approaches to overcome these constraints. The publication includes actual examples and case studies to illustrate the strategies and communicate the lessons learned.

This work was undertaken by three main working groups, comprising representatives from different IAEA Member States, which addressed: policy, legislative, regulatory and financial frameworks; technology and infrastructure; and societal and stakeholder issues. Overall project coordination was provided by the Coordinating Working Group, comprising the working group chairs and representatives of two participating international organizations — the European Bank for Reconstruction and Development and the European Commission. The project was chaired by C.M. Gelles (United States of America).

The IAEA officers responsible for this publication were H. Monken-Fernandes and P.J. O'Sullivan of the Division of Nuclear Fuel Cycle and Waste Technology.

CONTENTS

SUMMARY

Managing the legacies from the activities associated with the development of atomic weapons programmes, from the use of nuclear energy for peaceful purposes and from non-nuclear industries which involve accumulations of radioactive material presents significant challenges to States. The types of facility requiring decommissioning include nuclear reactors and associated fuel cycle and research facilities related to electricity generation and the production of material for atomic weapons programmes, facilities for the production of radioisotopes for medical and other purposes, facilities using radioactive material in consumer products and facilities used for storage of radioactive waste. Radioactively contaminated sites may include research or defence sites, former uranium production sites and areas affected by nuclear or radiological accidents.

Extensive decommissioning and environmental remediation (D&ER) programmes have been implemented in many countries to deal with the above legacies. Although some States have achieved substantial progress, many are facing significant difficulties in implementing their programmes. This may be explained by a variety of issues: the absence or weakness of a national policy and framework; the lack of financial resources; the unavailability of adequate technology and infrastructure; and neglect of stakeholder[1] and political challenges. Continued failure to address the above liabilities may result in unacceptable health, safety and security risks to the general public and to workers and increased risks to the environment.

An analysis of the factors that hinder progress in implementing D&ER programmes has been undertaken, and actual experiences and potential solutions for overcoming these constraints have been documented within this publication, which also provides several pertinent examples and case studies illustrating the application of the suggested solutions.

The publication emphasizes that it is the responsibility of governments to put in place a clear framework for the decommissioning of disused nuclear facilities and for management of contaminated land. Political commitment is generally a major driving force for implementation of D&ER and, without this, significant progress is unlikely to occur. Other key elements necessary to facilitate the implementation and progress of D&ER programmes include the development of a physical and radiological inventory based on the characterization of facilities and sites requiring attention, strategic planning, selection and implementation of appropriate technologies, good project management practices, and a robust stakeholder communication and engagement plan covering the life cycle of the D&ER programme.

Much can be and has been learned through the detailed analysis of the progress achieved throughout the world to address similar legacy issues. These insights can be applied to achieve greater progress where similar liabilities currently exist, as well as to provide information for existing and new facilities so that future liabilities are minimized.

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[1] Generally, the term ‘stakeholder’ can be defined as any institution, group or individual with an interest or a role to play in a societal decision making process. In the field of environmental remediation, the IAEA refers to stakeholders as individuals or organizations which may have an interest in the results of an environmental decision or be affected by that decision. In the context of decommissioning, the IAEA recognizes that the concept of stakeholder in the nuclear field is often limited to the public in general and public opinion groups and that it should be wider than those living in the vicinity of a nuclear facility being decommissioned but could be physically situated anywhere.

1. INTRODUCTION

1.1. BACKGROUND

Since the Second World War, the use of radioactive material has grown steadily, initially in the context of military applications and subsequently through a wide range of industrial and medical uses. As part of the normal life cycle of a nuclear or other facility that uses significant quantities of radioactive material, the last phase is normally the decommissioning of the facility, including its release from regulatory control. If the control of radioactive material is not properly maintained during normal operations, the environment may be contaminated and will require remediation. In addition to new facilities and those still operating, there are currently many facilities that have served their original purpose and are now shut down, including legacy facilities; the latter provide special challenges, since ownership is sometimes uncertain and on-site controls may have been reduced, allowing conditions to deteriorate. Legacy sites in which radioactive materials have been deposited without due consideration of safety implications, for example in cases where regulatory controls were lacking or absent, may also need to be remediated.

In order to understand the magnitude of the D&ER effort required, an overview of liabilities has been prepared. It is estimated that there are over 30 000 facilities worldwide that use radioactive material that will require eventual decommissioning [1]. From an environmental remediation perspective, there is no authoritative published estimate of the total amount of land that will require remediation; however, there are over 400 000 km^2 of former nuclear weapons test sites that are potentially contaminated. In addition, there exist large quantities of mill tailings (200 million tonnes in the United States of America alone) [2] and large areas of land contaminated due to radiological accidents (several thousand km^2) that will require eventual remediation.

A number of Member States have identified issues that have hampered the implementation of effective D&ER planning and implementation. As a result of Member State requests, and in the course of Side Events to the IAEA General Conferences in 2010, 2011 and 2012, the IAEA was encouraged to undertake activities in order to better understand the global situation and to establish mechanisms to analyse, and report on, constraints inhibiting the implementation of national D&ER programmes.

In response to this request, the Constraints to Implementing Decommissioning and Environmental Remediation (CIDER) project was initiated in 2012 with the objective of identifying constraints or issues that can impede the completion of projects and provide solutions that will allow successful implementation of D&ER projects in the Member States. A more detailed discussion of the organization, objectives and implementation of the CIDER project is provided in Appendix I.

1.2. OBJECTIVE

The objective of this publication is to identify constraints that can impede the decommissioning of facilities and environmental remediation of contaminated sites and to identify possible solutions to mitigate these constraints, thus enabling greater progress to be achieved. The publication is intended for senior decision makers, legislators, regulatory authority personnel, owners, project implementers, and planners involved in the decommissioning and remediation of a wide range of nuclear or radiologically contaminated facilities and sites.

1.3. SCOPE

This publication is concerned with addressing the legacy from the early development of nuclear energy. This includes:

(1) The dismantling of disused facilities used for nuclear energy production and for research, radioisotope production and nuclear fuel cycle activities;

(2) The remediation of former nuclear sites and those affected by past uranium mining and processing operations or by other activities involving the use of naturally occurring radioative material or by major nuclear or radiological accidents.

Section 2 is specifically applicable to legislators and other high level decision making governmental officials to aid understanding of the issues concerned with planning and implementing a decommissioning or environmental remediation project. Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.4. STRUCTURE

Section 2 is a high level summary that is designed to provide decision makers with the information needed to understand the issues that can be encountered during D&ER activities that could hamper the performance of a D&ER project.

Sections 3–6 provide detailed information on constraints that inhibit D&ER projects arranged by subject matter and provide solutions based on past projects to resolve these issues. Examples where these constraints have been mitigated on past projects are provided where applicable. Section 3 provides constraints and strategies associated with national policy, as well as the implementation of an overall legal and regulatory framework. Section 4 provides information concerning constraints involving the accessibility of technologies that can be used for D&ER, constraints associated with the lack of the infrastructure to apply the technologies, and constraints associated with implementing a waste management programme. Resource constraints and strategies, including financial, personnel, risk and life cycle management issues, are discussed in Section 5. Section 6 provides information on societal issues and the constraints and strategies associated with stakeholder communication and engagement throughout the life cycle of a D&ER programme.

Section 7 summarizes the major constraints that have challenged and continue to challenge D&ER progress throughout the world and identifies a path forward to ensure that lessons are learned from past projects.

Appendix I provides an overview of the IAEA CIDER project and the scope of D&ER liabilities the project and this publication address. Appendix II identifies funding mechanisms and cooperation programmes that may be used to support D&ER activities. Appendices III–VIII provide case studies that illustrate methods for overcoming constraints that have been identified in this publication. Appendix IX provides specific examples relating to the management of societal constraints.

2. OVERARCHING PRINCIPLES AND CONSTRAINTS RELATED TO PROGRAMME IMPLEMENTATION

The political environment in which decisions are made concerning the implementation of D&ER programmes is complex, with many non-technical factors bearing on the decision making processes. In certain situations, political decision makers may not have access to adequate technical resources, information or experience required to facilitate well informed decisions.

It is the responsibility of governments to put in place a clear framework for the decommissioning of nuclear facilities and for the management of contaminated land. Political commitment is generally a major driving force for implementation of D&ER, and without this significant progress is unlikely to occur.

There are three main principles related to the sustainability of nuclear activities that should underpin the practical arrangements put in place for D&ER activities:

(a) The safety of current and future generations;
(b) Ensuring the assembly and preservation of financial, technical and scientific resources for the decommissioning of nuclear facilities and remediation of contaminated sites (i.e. establishing the principle of ‘the polluter pays’);

(c) Intergenerational equity, according to which the generation that incurs long term liabilities should take responsibility, and provide appropriate resources, for the management of these liabilities in a way that will not impose undue burdens on future generations.

Implementation of D&ER may bring economic benefits to the facility owner and to the local community, for example through providing encouragement for the development of new businesses that will create employment local to the facility or site, increase property values and provide potential redevelopment opportunities. This will also increase societal confidence in the ability of governments and the nuclear industry to deal with the long term consequences of past and future nuclear activities. There are some situations where existing contamination may have potential implications beyond national boundaries. In these cases, collaborative arrangements need to be put in place to foster the building of trust between people of neighbouring countries sharing a common environmental concern.

There are a number of constraints or issues that can cause decommissioning or environmental remediation activities to be ineffective or even fail. These constraints may be grouped into four main categories: national policy and legal and regulatory frameworks, technological issues and enabling infrastructure, resource and programme management constraints, and societal and stakeholder concerns. Each of these categories is identified and briefly described below and more detailed information in provided in the subsequent sections of this publication.

2.1. NATIONAL POLICY AND LEGAL AND REGULATORY FRAMEWORK

In some States, the legislative basis may be incomplete or even non-existent. An essential requirement is that the national government develops a national policy that specifies national roles and responsibilities, and provides the basis for putting in place the legal or regulatory framework. This framework comprises a set of legal arrangements for the regulatory processes, and ensures that an independent regulatory body is established to regulate all aspects of the D&ER activities, encompassing arrangements for the approval and ongoing oversight of project activities. Closely associated with the establishment of the regulatory body is the development of regulatory policy, addressing strategic issues such as the regulatory approach and its application to the whole regulatory process, and the development of appropriate standards to assure the protection of people and the environment. This set of policies and framework should be based on an understanding of the inventory of liabilities that need to be addressed and of the relative safety risk resulting from individual facilities, and will ensure that D&ER projects are implemented in accordance with national safety goals and meet all relevant national commitments.

2.2. TECHNOLOGICAL ISSUES AND ENABLING INFRASTRUCTURE

Although technologies now exist to perform all typical D&ER activities, there is often a lack of accessibility to a required technology within a particular Member State, for example due to the lack of experienced personnel that have used the needed technologies and the lack of an infrastructure to support the effective use of the technologies.

In the context of D&ER of radioactively contaminated facilities and sites, the technology used to meet the overarching goals has a major impact on the performance of the project. In order to meet requirements for D&ER, many technologies for radiation protection, radiological characterization, decontamination, dismantling and waste management have been successfully applied. It is evident that current technologies are available to decommission or remediate all currently used facilities and sites. However, these technologies may need modification or adaptation to be used at specific facilities in order to enable implementation, and also to make the process safer, more efficient or less costly. Decisions related to the selection of technology need to be made on a case specific basis, considering the expertise and infrastructure available to support the selected method. Initial investment and total programme costs will also be strongly influenced by these decisions. New and innovative technologies should be promoted to make D&ER projects safer and to promote their implementation more quickly and cost effectively.

2.3. RESOURCE AND PROGRAMME MANAGEMENT CONSTRAINTS

D&ER activities are generally implemented as major projects, with similar resource needs as those applying to implementing other major projects, including: having access to necessary funds when required; availability of competent personnel for project planning and implementation: and having an appropriate national system for management of waste or other material originating from the project. The extensive array of project responsibilities and activities requires broad familiarity with, and understanding and working knowledge of, engineering (nuclear and non-nuclear) and managerial skills, including having an understanding of risks to project implementation and managing these risks (e.g. supply chain management). Good project management is a fundamental necessity for the successful and efficient implementation of D&ER projects. These attributes are necessary to ensure that projects achieve planned technical and safety objectives and are accomplished on schedule, within agreed budgets and in accordance with the envisaged scope. The high cost, complexity and longevity of large size D&ER projects demand a well structured management approach, predefined responsibilities and levels of authority for project implementation, and dedicated planning and control systems. These generally accepted management practices serve as a foundation for identifying the specific aspects of D&ER of radioactively contaminated facilities and sites.

2.4. SOCIETAL AND STAKEHOLDER CONCERNS

Stakeholder opinion and expectations are important elements of the decision making process for D&ER programmes and can represent a significant challenge to their implementation. Past experiences have shown that D&ER activities tend to be more effective if communication and stakeholder involvement is planned at an early stage. Good communication strategies will establish trust, cooperation and understanding between different interested parties in D&ER projects. D&ER programmes will be more effective if they respect the societal, ethical and cultural dimensions of all involved groups. This requires open, clear and agreed upon lines of communication among stakeholders within a well defined legal framework. A fundamental goal of stakeholder involvement is to facilitate a consensus between the public, the project owner and the regulatory authorities on an acceptable D&ER approach. It should be borne in mind that a major challenge is for stakeholders with a range of technical and social backgrounds to come to informed consent on the implementation of the D&ER project; that is, 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.

The decision making process for D&ER programmes can be complex and have many political and technical concerns that can affect a large number of people and the performance of the overall project. By understanding the constraints that can challenge the completion of a D&ER project, and by understanding that solutions to overcoming these constraints that have been identified and implemented in past projects, the current facilities or sites that are involved can be successfully transformed from a liability to a potential resource for future use.

3. NATIONAL POLICY AND LEGAL AND REGULATORY FRAMEWORK

This section addresses policy considerations and the associated institutional framework, including legal and regulatory aspects. Important benefits of a national policy for management of D&ER liabilities include establishing the basis for D&ER programmes and providing visible political commitment not to pass undue burdens to future generations. National authorities have an important role in ensuring that programmes are implemented in such a manner that the protection of the public and the environment is optimized, with priority being given to dealing with those situations where the associated risks are greatest.

In terms of national policy and the legal and regulatory framework, a number of constraints were identified from the CIDER survey undertaken at the commencement of the project (see Appendix I):

(1) A lack of, or incomplete or ineffective, national policy;
(2) A lack of a legal and regulatory framework;
(3) Non-independence or ineffectiveness of the regulatory authority;
(4) A lack or incompleteness of D&ER regulations and standards or guidelines.

These constraints are discussed in the following, including possible consequences if they are not addressed, potential solutions to mitigate the constraint and examples of how particular solutions were implemented.

3.1. NATIONAL POLICY

National policy for D&ER defines the main responsibilities for programme implementation, whether by government or the private sector, and establishes the arrangements for collection and disbursement of funds [3]. National frameworks also need to make provision for the participation of a wide range of stakeholders, including the general public and especially local communities, with the aim of implementing decision making procedures that are open and inclusive and whose legitimacy is accepted by the participants.

Depending on the nature of the challenges and on the national legal system, national policy for decommissioning may be addressed together with, or separately from, policy for environmental remediation. In either case, the policy should be developed with the aim of achieving the following principles:

(a) To provide protection of people and the environment both now and in the future;
(b) To include a long term commitment to ensuring that sites and waste from the sites are properly managed;
(c) To provide continuity and efficiency in the use of human and financial resources;
(d) To provide open and transparent interactions with stakeholders.

In addition, national policies for remediation of contaminated sites should reflect the magnitude and scale of the potential hazard posed and should be linked with radioactive waste management policies in existence at that time [4]. The national policy needs to reflect national priorities, circumstances and the availability of human and financial resources. It may be influenced by a number of factors, such as the timing of site decommissioning or the release of sites for reuse. Potential developments in the field of D&ER need to be considered, which may be either of a regulatory or technological nature.

3.1.1. Absent, incomplete or ineffective national policy

National policy aims to identify any fundamental requirements for D&ER as well as allocation of national responsibilities and arrangements to provide resources. The absence of a national policy may result in the regulatory authority not having a clear mandate, and consequential delays in D&ER may occur. This may also result in a lack of motivation among facility owners to initiate D&ER. If the policy is not sufficient or complete, there may be a tendency for operators to begin D&ER projects, but without having established a clear end point, leading to possible inefficient use of resources and with an increased potential that such projects are ultimately unsuccessful.

3.1.1.1. Strategy to overcome constraint

Where national policy is lacking, a prerequisite to putting this in place is to understand the extent of the relevant liabilities and the risks presented to the public and the environment [3, 4]. If the policy is incomplete or ineffective, it needs to be reviewed and updated to represent the relevant liabilities and risks presented to the public and the environment. Such reviews can be provided through the various international organizations, for example the IRRS[2] and ARTEMIS[3] peer review services provided by the IAEA. The process of developing national policy for D&ER is similar to the process used to develop a national policy and strategy for safety in those Member States newly engaged in establishing the safety infrastructure for a nuclear programme, for example ensuring the identification of responsibilities and their progressive allocation to the relevant organizations involved in the development of the safety infrastructure [5].

Example

Following the Fukushima Daiichi nuclear accident, in Japan, in 2011, the Japanese Government enacted primary legislation, the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011, in August 2011, to provide a basis for the very extensive environmental remediation programme needed to address the consequences of the accident. This legislation took full effect from January 2012 as the main legal instrument to deal with all remediation activities in the affected areas, as well as the management of materials removed as a result of remediation activities. The Basic Principles based on the Act were published in November 2011, thus creating an institutional framework to implement remediation activities [6]. IAEA peer review missions undertaken in 2013 noted that Japan had achieved good progress in the subsequent remediation activities, in line with the established policy, including the coordination of remediation activities with reconstruction and revitalization efforts [7].

3.2. LEGAL AND REGULATORY FRAMEWORK

The legal and regulatory framework comprises a set of legal arrangements that establishes and underpins the regulatory process. It mandates one or more regulatory authorities to develop regulations concerned with D&ER activities and to regulate defined activities in accordance with such regulations. Where several authorities are involved, the legal framework defines the respective responsibilities of each authority, ensuring that all regulated areas will be addressed sufficiently, without duplication of responsibilities.

The legal and regulatory framework for D&ER needs to be aligned with other elements of the national legal system. The framework may be ‘dedicated’ (i.e. specific to D&ER projects) or can be ‘embedded’ in existing, generic national (nuclear) legislation and regulation. The framework can be set at various levels: in primary legislation, in secondary legislation (e.g. governmental decrees), in regulations issued by the regulatory authorities and in the nuclear licence and associated guidance. The specific approach adopted depends on the national legislative context.

Regulatory requirements may be very detailed and specific (i.e. ‘prescriptive’ regulation) or may be more general and goal based, allowing individual operators/licensees to propose detailed approaches for their fulfilment (i.e. ‘performance based’ regulation). There can be significant differences in approach, depending on the national regulatory system, linked to national custom and practice and based on cultural and historical traditions. However, any approaches need to be appropriate to the scale of the D&ER project itself; that is, more extensive regulatory requirements are needed in situations where high safety risks apply.

The following issues should be addressed during the development of the legal framework for D&ER:

(a) Justifying the content of the framework in term of risk and cost–benefit analysis;
(b) Verifying the fulfilment of international obligations as established in relevant treaties or conventions;
(c) Demonstrating that the framework reflects good practice, requiring public consultation and stakeholder engagement in environmental decision making, and that requirements are implementable and provide for adequate control;

[2] The Integrated Regulatory Review Service assesses both technical and policy issues of a regulatory nature against IAEA safety standards and, where appropriate, good practice elsewhere.

[3] The Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation addresses areas of radioactive waste and spent fuel management, control of the nuclear discharges to the environment, decommissioning of nuclear facilities, and environmental remediation of radiologically contaminated sites, in relationship with the development of national policy, legislation and regulation, financing, technology and societal issues on D&ER.

(d) Obtaining prior approvals from the regulatory authorities in the case of activities that may represent a safety risk to individuals or to the environment, such as radiation and nuclear energy based technology [8].

The effectiveness of regulatory policy governing D&ER is enhanced by ensuring its compatibility with specific national situations, which may be diverse. Although applying typical good practices to situations involving complex and widespread problems is generally a useful approach, particular caution should be applied in Member States experiencing significant resource or technology constraints or those having only a few sites or less diverse problematic situations (e.g. small numbers of abandoned mines and uranium tailings sites).

3.2.1. Lack of an adequate legal and regulatory framework

The legal and regulatory framework for safety needs to be appropriate for the range of relevant facilities and activities, from the use of a limited number of radiation sources in some Member States to a nuclear power programme in others. The CIDER survey results indicated that, in certain cases, legal and regulatory frameworks for D&ER are completely or partially absent (e.g. with no relevant regulations and without a regulatory authority responsible for D&ER). A potential for conflict between different regulatory bodies may also exist. The institution responsible for performing or regulating D&ER may also not be clearly defined. Each of these constraints may delay and challenge the implementation of a D&ER project.

3.2.1.1. Strategy to overcome constraint

Overcoming this constraint requires that steps be taken towards the development of primary legislation that establishes a robust legal and regulatory framework, for example based on IAEA Safety Standards Series Nos GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [9], and GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [10]. Where there is an incomplete or non-existent framework for D&ER, legacy owners and regulatory bodies could raise awareness of the need for primary legislation through, for example, a series of high level awareness meetings. It should be noted that such activities need to involve all stakeholders, given that decisions concerning the utilization of nuclear energy require a national commitment. In the interim, a Memorandum of Understanding could be established between the regulatory authority and the legacy owner to establish the framework under which the project would be implemented pending the establishment of a comprehensive legal and regulatory framework.

Example

An IRRS mission[4] performed in Ukraine in June 2008 found that the newly established regulatory body, the State Nuclear Regulatory Inspectorate of Ukraine, together with the complementary statutory framework represented a good basis for the creation of an independent and sustainable Ukrainian nuclear regulatory system. The team acknowledged the important efforts by Ukraine to establish a legislative system covering all aspects of the safety of nuclear and radiation facilities and activities. The peer review team identified difficulties in addressing all legal provisions specified in the numerous laws regulating all nuclear and radiation activities and facilities. Some overlap between different national regulations was noted, which could lead to inconsistencies and contradictory requirements. In general, however, the arrangements already established had proved to be effective and in line with international good practice.

[4] States may request an IAEA IRRS mission to identify opportunities for improving national regulatory systems. Such missions aim to strengthen and enhance the effectiveness of the national regulatory infrastructure of Member States in the fields of nuclear, radiation, radioactive waste and transport safety and security of radioactive sources — through review against IAEA safety standards and international good practice — while recognizing the ultimate responsibility of each Member State to ensure safety in the above areas.

3.2.2. Absent or ineffective regulatory authority

The main roles of national regulatory authorities are to ensure safety, environmental protection and security. In practice, they are responsible for:

- Establishing regulations for D&ER;
- Ensuring compliance with legal and regulatory requirements;
- Reviewing and approving D&ER programmes;
- Issuing authorizations or licences for D&ER activities;
- Reviewing monitoring programmes during and after D&ER;
- Approving control mechanisms for future land use;
- Reviewing and approving changes in procedures or methods;
- Assessing reports of abnormal occurrences;
- Conducting regular inspections and performing enforcement actions where necessary.

In carrying out these roles and responsibilities, ensuring the independence of the regulatory authority from the organizations and activities being regulated is essential. In some cases, the role of the regulatory authority includes communicating with other governmental organizations and conducting public consultations regarding the management of risks from D&ER activities. An ineffective regulatory process may result from a lack of enforcement power and poor organization within the regulatory authority, for example resulting from an absence of leadership or an inadequate management system, too little funding, and not enough professional staff or technical support.

Where the regulatory authority is not properly organized and positioned, D&ER programmes may lack direction and are more likely to fail. If the regulatory authority is not adequately independent from the organization implementing the D&ER programme, the programme may face challenges associated with low public confidence, too little transparency and accountability, and inconsistency with other initiatives. As a result, the programme mission may not be accomplished.

3.2.2.1. Strategies to overcome constraint

Substantial changes in national policy or law, organization, funding, staff and training may be necessary to support the establishment of an independent and effective regulatory authority [10–12].[5] Adequate resources should be provided to ensure the necessary competences. Reviewing national policy and law can be the first step in establishing an independent regulatory body in accordance with international standards, codes and agreements or recommendations. In situations where the government owns, and is responsible for, contaminated facilities and sites, the assignment of regulatory responsibilities among government organizations needs to be considered carefully to provide the necessary regulatory independence.

Example

An IRRS mission organized in Poland in April 2013 found that the nuclear safety regulator, the National Atomic Energy Agency (Państwowa Agencja Atomistyki, PAA) had been established firmly as an independent regulatory body and commended this practice. It was further noted that the PAA independently prepares and submits its budget to the Ministry of Finance without the involvement of the Ministry of Environment, its supervising ministry. The appointment of the PAA president is made, and eventually terminated, by the prime minister, with no fixed tenure being applied. The Mission recommended that the Government develop procedures to ensure that

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[5] The overall responsibilities of a regulatory authority regarding remediation activities are described GSR Part 3 [10]. The equivalent standard for decommissioning of facilities in provided in a companion publication [11]. Additional practical examples of a regulatory framework can be found in Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste [12]. The directive requires, among other things, that each EU Member State creates a competent regulatory authority, has a national policy for the safety management of spent fuel and radioactive waste, and establishes a national programme to implement the policy requirements.

removal of persons with executive safety responsibility within the PAA is robust against any unwarranted political influence.

3.2.3. Lack of or incomplete D&ER regulations

National regulations and associated guidance for D&ER are intended to ensure the safety of the workforce, the public and the environment during and after the implementation of D&ER projects. Their content should be in accordance with the national legal system, together with international standards, and should reflect proven practice. Regulatory requirements need to reflect a graded regulatory approach in line with the scale of anticipated D&ER projects; that is, requiring a greater degree of regulatory oversight of project design and implementation where there are substantial risks associated with the project.

It is good practice during the development of regulations to undertake a regulatory impact analysis and to provide confidence in the efficiency and effectiveness of the proposed regulations. Public outreach should be undertaken during the development of regulations to provide opportunities to stakeholders to provide comment before these are finalized.

Where regulations, standards and guidelines are incomplete or missing D&ER projects may begin but subsequently fail owing to poor coordination. Such projects may be poorly planned and managed, faced with an inconsistent regulatory approach or be subject to disputes between the regulator and the implementing organization.

3.2.3.1. Strategies to overcome constraint

Establishing D&ER regulations, standards and guidelines in accordance with international standards and best practices, and reviewing and amending existing standards will support the successful implementation and completion of projects. Regulatory systems can be either prescriptive, performance based or goal setting. The guidance and guidelines can be written to aid the operator in further understanding regulatory requirements, such as end state criteria, waste acceptance criteria and best practice. Besides requesting IRRS Missions, Member States may invite independent peer review missions such as those undertaken through the IAEA ARTEMIS review service.

Example

An IRRS mission to Greece in May 2012 noted that the financial framework did not have clear provision for funding mechanisms to cover the costs of decommissioning of facilities, remediation and disposal of radioactive waste. The IRRS Team stated that this should be developed in line with a radioactive waste management policy. The IRRS Team further recommended that the Government should establish and maintain a national policy and strategy for radioactive waste management including provisions for decommissioning of facilities, management of radioactive waste and related financial arrangements.

The IRSS Team recommended that radiation protection regulations should define requirements concerning predisposal radioactive waste management and decommissioning of facilities as part of an authorization process compatible with IAEA safety standards. It was also suggested that safety requirements for decommissioning of facilities and predisposal management of radioactive waste be established by the relevant national authority, the Greek Atomic Energy Commission.

3.3. SUMMARY

For D&ER to be effective, the government needs to establish a national policy that is supported by a robust legal and regulatory framework. The framework needs to identify the regulatory authority and assign relevant powers and necessary resources. The regulatory authority is most effective when it is independent from the operator; this provides accountability, confidence and transparency to the public. In those cases where national policy for D&ER or the legal and regulatory framework is incomplete, then this will restrict the influence that the regulatory authority has on the operator concerning the implementation of D&ER.

Table 1 summarizes the constraints related to national policy and legal and regulatory framework, and provides potential solutions to overcome these constraints. It also highlights where additional examples and experience can be referenced to inform Member States efforts to address similar situations.

TABLE 1. CONSTRAINTS AND SOLUTIONS RELATED TO NATIONAL POLICY AND LEGAL AND REGULATORY FRAMEWORK FOR D&ER

Constraint	Solution
Absent, incomplete or ineffective national policy	Establish a national policy in accordance with international standards, for example following a similar approach to developing a national policy and strategy for safety as in States embarking on nuclear energy programmes
Lack of an adequate legal and regulatory framework	A Memorandum of Understanding may be established as an interim measure to establish the framework under which the project will be implemented
Absent or ineffective regulatory body	National legal framework should require the establishment of an independent regulatory authority
	Establish necessary regulatory authority with independence from political or other interference through primary legislation
	Fund professional staff, consultants and a technical support organization, where required, to support the regulatory body
	Strengthen the regulatory authority through better leadership and management systems
Lack of or incomplete D&ER regulations	Establish new or revised D&ER regulations, standards and guidelines on D&ER in accordance with international standards and best practices

4. TECHNOLOGICAL ISSUES AND ENABLING INFRASTRUCTURE

This section addresses constraints related to technology and enabling infrastructure, including waste management and work environment issues and provides advice and examples on how these might be overcome.

4.1. LACK OF ACCESSIBILITY TO APPROPRIATE TECHNOLOGY

An important challenge to be faced is the transfer of technologies from States with more advanced programmes to those which are less advanced and the associated need to have access to qualified personnel to support their use and to provide regulatory oversight. Although it is clear from existing worldwide experience that D&ER projects can be implemented using currently available technologies [13, 14], it is also evident that the development of new technologies could improve the performance of D&ER projects by implementing them more efficiently, being safer to the public and the environment and involving less cost.

Decommissioning projects may require the use of specific technologies for decontamination, plant segmentation, building demolition, waste treatment and packaging, and radiological monitoring and analysis. For environmental remediation, technology selection may need to address, among others, site characterization and monitoring, modelling of the spread of contaminants, water treatment and engineered barrier and capping design. Accessibility to the appropriate technology for specific D&ER activities can be a major constraint for many Member States, either due to the non-availability of the technology in the Member State or the absence of personnel with relevant experience in its use.

4.1.1. Strategy to overcome constraint

Individual Member States may be able to select from several different possible strategies to overcome identified constraints:

— Purchase adequate technology and employ or contract personnel with relevant experience and knowledge in the use of that technology;
— National development of appropriate technology together with the establishment of national competency in its use;
— Development of new technology for a specific purpose, in particular in cases where available technologies would require significant development;
— A combination of the above strategies.

Depending on the Member State, the decision on the use or development of a technology is dependent on several factors (e.g. funding, infrastructure, existing technology, human resources and experience). In certain cases, a region may strive to become a national centre of expertise in the application of a particular technology.

Example

The Ignalina Nuclear Power Plant was an important component of Lithuania's energy sector since coming on line in 1983. In due course, in the context of its entry to the European Union in 2004, Lithuania agreed to the early shutdown of its reactors, Unit 1 being shut down in 2004 and Unit 2 being shut down in 2009. In accordance with the Ignalina Nuclear Power Plant Final Decommissioning Plan, the decommissioning process is organized into several decommissioning projects, generally following an 'immediate dismantling' approach. Each of these decommissioning projects covers a particular field of activity, for example initial primary circuit decontamination or dismantling of equipment according to a 'room by room' or 'system by system' approach. For each individual project a separate strategy and associated licensing documents are prepared, including selection and evaluation of appropriate techniques taking account of the applicability of different technologies in Lithuania and existing experience in their use. The dismantling strategy selection process applied at the Ignalina Nuclear Power Plant for decommissioning of the emergency core cooling system and auxiliary reactor systems is shown in Fig. 1.

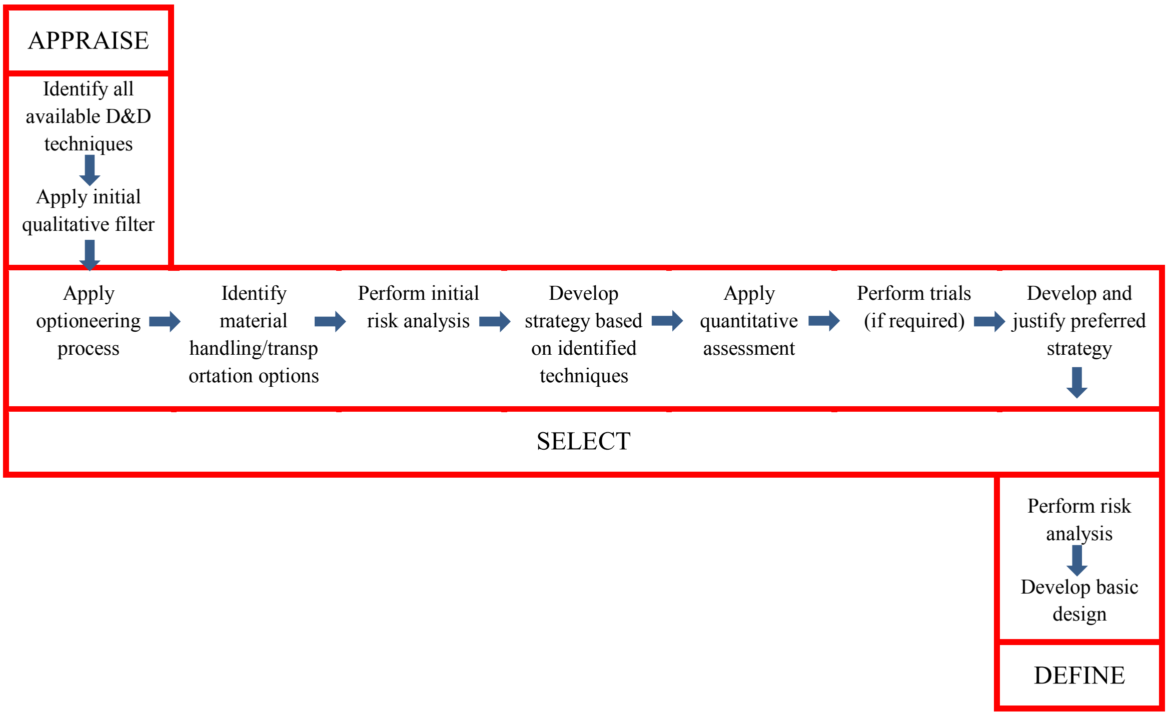

FIG. 1. Dismantling strategy selection process applied at Ignalina Nuclear Power Plant.

4.2. LACK OF ENABLING INFRASTRUCTURE FOR TECHNOLOGY IMPLEMENTATION

Appropriate infrastructure and methodological approaches, being the preconditions for the application of D&ER technologies, need to be developed in a timely manner to avoid delay in project implementation. The basic infrastructural elements needed to support technologies for D&ER projects include: access to adequate water supplies, electricity, roads, transport systems; services catering for subsistence needs of employees, including health care; and site security. Waste transport systems and access to a disposal or storage facility for waste generated during the project and remaining from the operational phase are also important requirements.

4.2.1. Strategy to overcome constraint

Wherever possible, available infrastructure should be identified prior to selecting specific technologies and methodologies for the implementation of the D&ER projects. In cases where the necessary infrastructure is absent, use of mobile systems may be an alternative. For example, it may be necessary to access a water reservoir or to manage the water supply for a site to be able to use equipment requiring large quantities of water (such as water cooled cutting machines), to suppress potentially contaminated dust or to wash buildings and equipment for decontamination purposes.

An adequate infrastructure to provide power supplies for all the necessary equipment needs to be established and maintained; bearing in mind that some equipment may use large amounts of electricity or have special requirements such as high current levels. This situation may present greater difficulties in the case of those legacy sites where the facilities and buildings have not been maintained over an extended time period and perhaps without access to electricity or power lines.

A similar situation can occur regarding road access to sites, making it difficult for site personnel to be transport to and from the site. Moreover, if a waste transport system is required to take material off the site or if the remediation techniques being used rely on the import of clean material from outside the site, conventional road access will be required. Establishing a temporary waste disposal or storage facility is a typical approach to overcoming infrastructure constraints in many countries when a permanent waste repository is not available. A more detailed discussion on this issue is provided in Section 4.3.

The provision of adequate security on D&ER projects is an important consideration, as there may be a risk of unauthorized invasions, especially in the case of a legacy sites. Consideration needs to be given to limiting access to the area by fencing off the perimeter area and establishing security monitoring systems in order to ensure contaminated material is not diverted from the site and the public does not have access to the site, thereby ensuring their protection.

4.3. LACK OF MANAGEMENT SYSTEMS FOR WASTE ARISING FROM D&ER PROJECTS

An absence of waste disposal routes is generally a major constraint to implementing D&ER projects and is likely to be a major factor in strategy selection, for example:

- Deferred dismantling and safe enclosure options may need to be used, at least for certain facilities on the site;
- Immediate dismantling may require the commissioning of an interim storage facility;
- Construction of on-site disposal facilities for waste resulting from the cleanup and decontamination operations.

4.3.1. Strategy to overcome constraint

A waste management plan that describes the disposition pathways for all types of waste generated as a result of D&ER activities should be developed. The waste management plan should reflect:

- Characterization results;
- Identified D&ER end state such as unrestricted or restricted use;
- Site redevelopment plans, if available.

The radioactive waste management programme should address:

(a) Types and quantities of waste stream expected.
(b) Disposition pathways.
(c) Options for management of the main types of radioactive waste.
(d) Implementation of a waste management hierarchy, incorporating:
    — Waste minimization;
    — Recycling and reuse of materials;
    — Clearance of materials where possible.
(e) Infrastructure for waste handling, conditioning, transport and disposal.

4.4. CONSTRAINTS DUE TO WORK PLACE ENVIRONMENT

The risk of injury to workers during D&ER is an important consideration when planning for D&ER, and steps need to be taken to mitigate the risks prior to initiating a project. For example, many D&ER projects are either initiated in a highly contaminated environment, or a contaminated environment is created via the D&ER process. Factors to consider when evaluating this constraint include the following:

— Amount, concentration and form of contaminated or activated material distributed over a single installation and over the surrounding area;
— Presence of highly contaminated materials such as spent nuclear fuels or high activity material such as spent radioactive sources;
— Toxicity of non-radioactive contaminants (chemicals);
— Types of radioactivity in the contaminants (alpha, beta and gamma emitters) and consideration of the associated exposure pathways (e.g. inhalation, ingestion, injection and skin exposure);
— Complexity and diversity of equipment, systems, buildings and components;
— Undefined or unknown levels, types and locations of contamination or sources in very old equipment;
— Unanticipated sources of contamination or radioactive sources;
— High radiation fields — where worker access is extremely limited.

4.4.1. Strategy to overcome constraint

Development of a comprehensive integrated management system will help to mitigate this constraint. A comprehensive radiation protection programme and industrial safety programme with use of appropriate protective equipment and properly trained personnel are essential. The safety assessment report should describe all significant risks to the workforce, both radiological and conventional, and should explain the measures that need to be taken to ensure that residual risks, once these measures are implemented, are sufficiently low to be compliant with the relevant safety standards, including requirements to optimize protection. It is good practice to have in place a risk management plan which describes each risk, its probability of occurrence and the associated consequences and the measures that should be taken to ensure that the risk remains at an acceptable level.

Example

During the decommissioning of a nuclear reactor, workers may have to decontaminate concrete in very narrow spaces using a rock chisel, and access to such spaces, which may be located up to 10 m below ground level, may require the use of scaffolding and ladders. In such situations, operators are sometimes required to wear fully protective suits, with a respirator, in situations where the radiological risk does not require such protection, with the result that movement in such confined spaces becomes unnecessarily hazardous. It is important that personnel protective equipment requirements are commensurate with risk and adapted to the work as over classification may increase actual risk to workers.

4.5. SUMMARY

Summary of strategies that have proven successful in overcoming issues related to lack of the infrastructure to support the use of technologies applied during D&ER are provided in Table 2.

TABLE 2. SUMMARY OF CONSTRAINTS AND STRATEGIES: TECHNOLOGY AND ENABLING INFRASTRUCTURE ISSUES

Constraint	Solution
Lack of accessibility to appropriate technology	Purchase adequate technology together with the experience and knowledge of technology usage National development of appropriate technology together with enhancement of national competency for technology usage
Lack of infrastructure to implement technology	Establish portable laboratories located on the D&ER site Use temporary trailers or buildings
Lack of waste management system for wastes arising from D&ER projects	Prepare a waste management plan Identify alternative options if waste disposal sites are not available (e.g. construction of interim storage facilities)
Constraints due to workplace environment	Development of a comprehensive integrated management system Implement a risk management plan
High risk workplace environment	Perform a comprehensive characterization survey Perform a hazard analysis and prepare a safety assessment Develop a robust radiation protection and industrial safety programme
Absence of temporary waste disposal facility	Construction of temporary waste disposal or storage facilities
Lack of basic infrastructure systems such as water, electricity and sanitary facilities	Use portable tanks as temporary water sources, mobile generators for power and portable latrines
Lack of radiation and industrial hygiene laboratory facilities	Establish portable laboratories located on the D&ER site

5. RESOURCE AND PROGRAMME MANAGEMENT CONSTRAINTS

This section discusses constraints, and associated strategies for their management, relating to the planning and implementation of D&ER projects, including aspects concerned with identifying and securing financing, project planning, management and implementation, including contracting and human resource issues.

5.1. ENSURING ADEQUATE FUNDING AND COOPERATION

D&ER projects typically have long time frames and high costs. Thus, in accordance with the principle of intergenerational equity discussed in Section 2, it is important to ensure the provision of appropriate funding to enable ongoing D&ER liabilities to be addressed. A lack of identified and available funding will impede the implementation of D&ER programmes and, while this financial constraint can generally be mitigated through the definition and establishment of financial arrangements as part of the enabling national policy and framework (see Section 3), liabilities may exist for which financial provisions are not fully identified.

5.1.1. Primary sources of funding

The ultimate responsibility for nuclear legacies rests with the state where the relevant site is located, as reaffirmed by the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [15]. For privately owned facilities, financial responsibility rests with the facility owner, unless the owner cannot be identified or is no longer known. Thus, the primary source of finance for D&ER projects is the facility owner, being either the State or a private owner. In certain, limited cases, this might be complemented by international resources.

5.1.1.1. Strategy to overcome constraint

Funding needs to comply with the ‘polluter pays’ principle (which emphasizes the responsibility of the operator and aims to ensure that costs are not recovered from general taxation), sufficiency (the funds have to be enough to complete the D&ER tasks), availability (the funds have to be available at the appropriate times) and transparency (the funds have to be used only for D&ER, and their management has to be clear, auditable and transparent). Generally, a legal framework is established to ensure and enforce these requirements.

Three main types of funding model 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 to the situation where the facility is owned by the state, which is the case for many research reactors and legacy sites. In this situation, costs are either paid annually from the state budget, or contributions are made to a decommissioning fund that accumulates over time.

In the internal segregated or non-segregated fund models, the operating organizations are responsible for amassing the funds during operation and managing the financial resources until needed. 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 only for 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 State) or dedicated to each operator.

There are several options to raise the necessary funds. This can be done through annual payments made 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) on the benefits of the commercial activity of the operator.

However, regardless the specific advantages and disadvantages of each of the funding models and mechanisms to raise the funds (i.e. an external segregated fund could have advantages over internal funding with regard to transparency), there are inevitable uncertainties about actual costs and therefore risks concerning the availability of adequate funding. To minimize such risks, it is essential to have a complete inventory of the liabilities and an accurate estimation of the cost of the D&ER activities. This depends on a number of factors, of which the implementation strategy is one of the most important. Accurate assumptions about relevant future price inflation, discount rate, value of the asset and shutdown date (including the risk of premature shutdown), among others, are also significant factors to consider when developing efficient and successful funding arrangements.

A thorough analysis of the options, requirements and risks is essential, taking account of the characteristics and nature of the D&ER projects to be funded, in order to select the most appropriate funding arrangement for a particular State or facility or site owner.

Example

A significant proportion of civil nuclear liabilities of the United Kingdom are state owned, and include: the first generation gas cooled (Magnox) reactors; the fuel cycle sites at Sellafield, Dounreay, Capenhurst and Springfields; and the waste disposal facility at Drigg, in Cumbria. These liabilities are managed by the Nuclear Decommissioning Authority on behalf of the state and funding is provided directly from the state budget. The second generation gas cooled (Advanced Gas) reactors are owned by a commercial organization, EDF Energy. Funds for the decommissioning these stations will be provided from an external segregated fund with an independent board of trustees.

5.1.2. Potential complementary funding sources

Some States that have been active in the nuclear energy fuel cycle since the 1950s may nonetheless have little experience of implementing D&ER projects. In certain situations where funds were established to support D&ER activities during operation of the facility, the amounts proved inadequate owing to price inflation, increases to disposal costs, poor initial cost estimates, a lack of fund management expertise, and reassignment of collected monies due to other national priorities. There are also cases where the funds were just not collected during operation, especially with government owned facilities, because it was decided that the funds would be available through the normal budget cycle of the country, but this assumption has often proved difficult to realize owing to competing demands on State budgets. There are also cases — specifically concerning environmental remediation — where the activities that led to the contamination of the sites in one State were undertaken by a different State and which is no longer willing to bear the costs of the cleanup operations.

5.1.2.1. Strategy to overcome constraint

Involvement of international funding institutions may facilitate access to international expertise and international best practice. Their involvement can also lead to enhanced credibility in terms of increased openness and participation by local communities in D&ER activities. If funding provided by these international organizations were not available, it is probable that some States would 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.

Appendix II describes the role and activities of a number of major international funding organizations active in funding D&ER projects, in particular the European Bank for Reconstruction and Development (EBRD) and the European Commission.

Example

The Bohunice V1 nuclear power plant in Slovakia, Units 1–4 of the Kozloduy nuclear power plant in Bulgaria and Units 1 and 2 of the Ignalina Nuclear Power Plant in Lithuania were shutdown earlier than originally planned as a result of the accession of these States to the European Union. No substantial funding had been set aside by these plant owners to cover the decommissioning costs. To assist the implementation of decommissioning, the European Union and other donor States agreed to provide substantial grant assistance to help to cover the decommissioning costs. The EBRD acts as the manager of the three relevant International Decommissioning Support Funds (IDSFs) (see Appendix II).

5.2. LACK OF HISTORICAL KNOWLEDGE (CHARACTERIZATION DATA, UNCERTAINTY OR UNKNOWN RISKS)

Lack of historical knowledge and characterization data, in particular for legacy D&ER sites that have been in a state of long term shutdown or abandoned, is a major obstacle in initiating D&ER projects and can present safety issues for D&ER personnel who are accessing the site for the first time. The types of hazard that might be encountered during D&ER projects include:

- Location of unknown or poorly defined sources of contamination and radiation;
- Unknown physical condition of structures and systems;
- Exposure to dangerous amounts of radioactivity;
- Exposure to hazardous material and chemicals such as asbestos and mercury.

The types of historical records that are of particular value include the following:

- Site and facility description (including engineering drawings and diagrams, and design modifications);
- Operating records (e.g. radiological surveys, effluent releases and waste documentation);
- Safety records (e.g. personnel exposures and survey reports);
- Site licence and permit information (if any);
- Process knowledge (collected via personnel interviews);
- Documentation of abnormal events.

5.2.1. Strategy to overcome constraint

Characterization data should normally define the nature and extent of radiological contamination or activated material, including the identification of contaminated media types (e.g. structural surfaces, soil, surface water, groundwater, equipment, system components, vegetation and constructions), and the identification of the radionuclide profile and extent (area and depth). In addition, an inventory of hazardous non-radioactive materials, such as asbestos, provides for consideration of additional protective measures required to prevent harm to human health. Collectively, the data are crucial to the understanding and definition of the risks associated with the project.

In situations where characterization data are either missing, or the available data are untrustworthy, there is little option but to implement a detailed characterization survey. This entails the development of a characterization plan that lays out the data that will be collected, the level of measurement accuracy that is needed and how data collection process will be phased. Decisions also need to be made concerning the methods of data storage and on the extent to which radiological data are linked to a representation of the physical structure (e.g. developed using computer aided design technology).

Example

For the Siloé research reactor decommissioning in Grenoble, France, the original strategy was to dismantle the research reactor and its liner after emptying the pool water (which had been in contact with the reactor). The selected strategy was based on the available information concerning the in situ radiological conditions. Pool emptying commenced following completion of the dismantling of the reactor internals. During this phase, however, an unforeseen high dose rate was found near the top of the pool. Work was stopped and intensive characterization performed to investigate the source of this unexpected activity. It was discovered that during the erection of the facility, neutron beam channels were erected with the tubes not sufficiently close to the concrete, such that neutrons were not contained and had activated the reactor structure. A new measurement characterization campaign was undertaken and the dismantling changed from a hands-on approach to a remotely operated one involving the use of a carrier and manipulator.

5.3. LACK OF QUALIFIED PERSONNEL

The workforce needed for successful implementation of a D&ER project comprises two main categories of personnel: facility operators and D&ER specialists. Skilled personnel with knowledge and experience of the facility or site to be decommissioned or remediated is essential for obtaining historical information. Knowledgeable and skilled personnel in D&ER tools and techniques is also required to successfully plan and implement the D&ER activities.

The timescales for D&ER projects are typically very long, for example the time elapsed from the design of a nuclear facility or site and its D&ER can reach several decades, and important knowledge, such as hardware configuration, accidents and site characteristics, may be lost. In addition, experienced members of the operational workforce may leave or retire, as in many cases knowledgeable and skilled personnel might not be interested in decommissioning or remediation jobs.

The implications of a lack of skilled and experienced personnel (at the facility level) can be more serious in those cases of one-of-a-kind installations with many specific characteristics, both in design terms from the perspective of operations. This constraint can be aggravated further in cases where there is a discontinuity in the life of the plant, such as long periods of safe conservation or extended shutdown period.

5.3.1. Strategy to overcome constraint

The strategy adopted to overcome this constraint will vary according to the facility location. In those cases where the facility has been a major employer in the area, significant efforts will tend to differ depending on the level of importance of the facility to the economy of the surrounding area. Significant efforts are generally are made to ensure that former operators are reskilled in order to be able to undertake the decommissioning activities. A vigorous retraining programme can assist facility operations personnel to become successful D&ER workers for certain tasks. These staff will need to be supplemented by specialist contractors for operations such as segmentation work undertaken in areas with high dose levels. For situations where the facility has not been a major contributor to the local economy, greater reliance is generally placed on the use of contractors with experience in D&ER projects and with access to appropriate human and technical resources.

5.4. LACK OF ENABLING PROGRAMMATIC INFRASTRUCTURE

In situations where Member States' efforts to implement D&ER programmes face challenges, including limited financial resources, it is vital that the development of high quality plans consider numerous factors and good project management practices. These factors, practices and systems comprise a programmatic infrastructure that is vital to support optimal planning and implementation of D&ER activities. Many of these factors are summarized below, based on feedback received to the CIDER survey, discussion among Member States participating in the CIDER project and on review of past D&ER programmes throughout the world.

5.4.1. Lack of contract and procurement planning expertise

Most D&ER projects require the use of specialist contractors to a greater or lesser extent depending on the range of in-house resources available to the facility owner. This requirement may relate to services or specialized equipment. The process of finding appropriate contractors or equipment in itself requires the use of significant expertise, addressing procurement, legal and contract management aspects. A lack of such expertise inside the owner's organization may constitute a significant constraint to project implementation. For example, the absence of a competent contract procurement capability could lead to the hiring of inexperienced D&ER specific contractors or the purchase of inappropriate equipment.

5.4.1.1. Strategy to overcome constraint

Establish a strong procurement and contracting policy that can be implemented when evaluating and contracting specialist personnel and for equipment purchase. When the capability to perform D&ER activities is not fully available in-house, additional competencies may need to be procured. It is important to consider many factors during the procurement process — primarily the qualifications and experience of the contractor (i.e. the company from which services are to be procured). When evaluating a contractor, the following factors should be considered:

(a) Is the contractor experienced in the same or similar types of work?
(b) Does the contractor have standard operating procedures and demonstrated experienced personnel?

(c) Does the contractor hold the necessary certifications and associated quality management system commensurate with the expected quality assurance requirements of the project (e.g. ISO 9001 certification)?
(d) Can the contractor demonstrate an acceptable level of performance standards via assessment or audit reports or other types of performance evaluation testing?
(e) Does the contractor have the necessary capacity and infrastructure (e.g. cadre of trained and qualified personnel, in-house equipment, and an ability to quickly procure equipment and services when required) to perform the work within the desired time frame?
(f) Does the contractor routinely perform internal reviews, assessments and audits to assure consistent high quality work? And is this information readily available to the procuring organization?
(g) Can the contractor (if located outside of the Member State where the activity will be performed) demonstrate experience working outside of their country of origin?

5.4.2. Ensuring competencies and dealing with cultural change

D&ER is often concerned with facilities that are located on sites where much of the workforce were formerly employed at the same facility during its operational life. These workers may have a natural bond to the facility and may have some difficulty adopting a mindset associated with its removal in an efficient way, for example they may have a tendency to want to undertake research into the development of novel technologies that are not strictly necessary for project implementation. The former operational workforce may also have some difficulty adopting working methods appropriate to a dynamic project environment as opposed to a more routine process environment.

The management and organizational culture required for decommissioning of nuclear facilities and environmental remediation of contaminated sites is different from that for operation of such facilities and sites. Operation is essentially a process based on an essentially standard routine and training can be planned and tested on that basis. For D&ER projects, the nature of tasks is more dynamic and as a result more flexibility is required to adapt to unexpected situations.

5.4.2.1. Strategy to overcome constraint

Development of an effective organization for D&ER projects should start with engaging and retaining staff resources of the existing operating organizations. Their knowledge of the design and operational history is essential for the definition of D&ER projects. However, new skills and experience are needed, including, but not be limited to:

— Project management;
— Commercial and cost management;
— Planning;
— Monitoring progress and reporting;
— Risk management;
— Interface management with the relevant authorities.

Operational craft and technician personnel will also require retraining and cultural change to ensure D&ER tasks will be performed in a safe and efficient manner. In conjunction with utilizing or retraining existing staff, supplementing the project team with external professional staff will accelerate the development of efficient D&ER organizations.

5.4.3. Importance of inventory

An inventory of facilities and sites requiring D&ER provides a basis for prioritization of D&ER activities. Subject to the availability of relevant information on individual facilities, this will allow a risk assessment to be undertaken and the costing of different options for D&ER. Ideally, such information should be collected and maintained centrally by an organization identified by the government or owner 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, socioeconomic, hydrogeological and environmental data;
— The owner’s identity;
— The location;
— The size of the site or facility;
— The type of facility or activity;
— The number, size and type of buildings, containments and other structures;
— The type and condition of equipment;
— A description of tailings;
— The number and condition of waste storage facilities or waste dumps;
— Available infrastructure;
— Characterization of data on radiological and chemical hazardous substances.

5.4.3.1. Strategy to overcome constraint

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

5.4.4. Risk based prioritization

The lack of a risk based prioritization of contaminated facilities and sites can be a significant constraint to the implementation of D&ER programmes, especially in countries with a large number of contaminated sites and legacy facilities. Without risk based prioritization, it is unclear which sites and facilities warrant urgent action, leading to potential competition for limited resources among widely varying sites and facilities.

5.4.4.1. Strategy to overcome constraint

States with large numbers of contaminated sites should define prioritization mechanisms in their national policy. To fulfil this objective, two fundamental premises are required: one is to have a comprehensive inventory of the facilities and sites that could need to be decommissioned or remediated including the assessment of their risks and possible remedial strategies, the second is to establish a scheme for prioritization in order to ensure an optimized use of the available resources while appropriately addressing the legacies.

The prioritization should be based on a risk assessment for each facility and site. This should take into account the risks for public and the environment of the then existing situation of the facilities or sites, such as the status of conservation, stability of the containment and structures, and waste characteristics (volume, physical, chemical and radiological properties, leakages or other incidents). Using appropriate methodologies, the objective of the risk assessment is to estimate and quantify the risk associated with each site in a way that allows comparison of different site situations.

The assessment should also integrate the consequences of potential accidents, for example those provoked by extreme external events (i.e. earthquakes, floods, extreme rain and landslides). Essential factors are the proximity to surface or underground water courses and the population that could be impacted in the vicinity.

5.5. SUMMARY

All D&ER projects are very resource intensive and require good project management to ensure a successful completion of the project. The lack of appropriate funding, properly qualified personnel and historical knowledge are the three main resource related issues that have the most effect on a D&ER project. There are other constraints identified in this section that also affect the performance of the project, but they are of a lesser degree. Table 3 summarizes these constraints and provides ways of minimizing the effect of these constraints on the project.

TABLE 3. SUMMARY OF CONSTRAINTS AND STRATEGIES: RESOURCE AND PROGRAMME MANAGEMENT ISSUES

Constraint	Solution
Inadequate funding and cooperation	Establish an independent D&ER fund early in the facilities life cycle to collect funds during operation Investigate other sources of funds from international organizations
Lack of historical knowledge (characterization data, uncertainty or unknown risks)	Perform a good characterization of the facility or site Interview current and retired employees
Lack of qualified personnel	Establish a retaining programme for operations personnel Hire D&ER specialists
Lack of contract and procurement planning	Prepare a contract procurement policy for D&ER projects Perform a thorough review of proposed contractors during the procurement process
Ensuring competencies and dealing with cultural change	Reorganize to ensure the organization is appropriate for D&ER activities, reflecting differences between an operational culture and a D&ER project culture Retrain operations personnel for new approaches to their work
Lack of an inventory of facilities and sites and associated hazards	Identify all facilities that will require D&ER Collect information that will allow prioritization based on risk

6. SOCIETAL CONSTRAINTS AND APPROACHES TO OVERCOME THEM

The purpose of this section is to present the major societal constraints which may be encountered when implementing D&ER programmes. Various strategies to address or overcome these constraints are presented along with examples of existing practices related to the integration of societal aspects in D&ER programmes worldwide.

Societal and stakeholder involvement constraints differ in nature from the previous constraints addressed in the previous sections of this publication, as they mostly relate to the demands of different stakeholders [16, 17]. Regardless of their origin, they also represent barriers to implementation and can have a significant impact on the costs and schedule of the project. There are limits to the extent that societal issues may be considered separately from other factors, as a full understanding of societal issues can only be obtained by considering these in combination with non-societal factors, as there may exist complex interlinkages between all of these.

In this publication, the discussion of societal issues has been limited to how D&ER programmes are implemented in line with principles of social justice and how they are influenced by societal perspectives. Societal constraints arise mostly as a result of the different perceptions, attitudes, opinions and concerns of stakeholders towards the risks and benefits of D&ER programmes and because of an absence of stakeholder involvement planning. Societal constraints can obstruct or delay the implementation of D&ER programmes or hamper the stakeholder involvement process associated with the D&ER programme. The constraints are connected and may influence one another.

In general, early engagement of relevant stakeholders should be a formal part of the early planning and approval phases of D&ER programmes. It is important to develop an effective communication and stakeholder involvement plan to improve mutual understanding and facilitate dialogue with interested parties (see Appendix IX, which lists various IAEA and OECD publications on this issue).

The societal factors that may constrain or influence the implementation of D&ER programmes are defined below. These factors are based on experience gained, investigations, evaluations and discussions taking place during implementation of D&ER programmes, leading to the identification and determination of those factors that were most significant. The following list of constraints includes the main impacts which are relevant to D&ER programmes, but is not exhaustive:

(1) Limited technical knowledge and understanding of the issue and process.
(2) Groups and individuals opposed to the programme.
(3) Concern related to the waste disposal on-site.
(4) Different demands and concerns between stakeholders.
(5) A limited budget to cover stakeholders' demands.
(6) A negative experience with D&ER programmes.
(7) A lack of support by governmental authorities to implement D&ER.
(8) Changing the administrative procedure and legal framework related to D&ER.
(9) A lack of trust between stakeholders.
(10) Little recognition of the links between environmental, economic, and social concerns.
(11) Constraints that hinder progress in stakeholder involvement, including:
   — An absence or ineffectiveness of national policy and legal framework;
   — Groups and individuals against the implementation of stakeholder involvement in D&ER programmes;
   — Complex procedures for involvement;
   — Changing positions within one group;
   — Limited capacity to express opinions in public;
   — A lack of funding sources to undertake involvement;
   — Limited access to information and communication;
   — Information overload;
   — A negative experience with stakeholder involvement;
   — Too little use of independent facilitation;
   — A lack of motivation to participate in the process;
   — Unrealistic expectations;
   — An absence of continual stakeholder involvement and communication;
   — A lack of balance between transparency and security.

The following subsections describe in detail each constraint, provide suggested approaches to overcome these constraints, and give practical examples which have been applied in various D&ER programmes worldwide. In addition, examples of actions on how to overcome constraints are highlighted in Tables 4 and 5, in Section 6.12.

6.1. LIMITED TECHNICAL KNOWLEDGE AND UNDERSTANDING OF THE ISSUES AND PROCESS

In general, the public has limited knowledge of nuclear and radiological concepts and, in addition, the highly technical nature of nuclear activities, and the history of secrecy often surrounding them in the past, may make stakeholders distrustful or even fearful. Where the overall life cycle of D&ER programmes is not understood, the licensing process may seem cumbersome, bureaucratic processes associated with these activities are often very complex and the opportunities for public involvement may not be evident at the outset. All these issues together can lead to a negative attitude among interested parties towards project implementation.

6.1.1. Strategy to overcome constraint

It is important to improve public knowledge by providing relevant and timely information in an understandable way. This process takes time and resources and should be continual. Before presenting the D&ER programme to be implemented, there is a need to identify the level of knowledge and understanding related to D&ER activities to be implemented among the different stakeholders. This can be done by conducting public opinion surveys, discussions, establishment of focus groups and coordination with local educational institutions, among other things. Analysis of the results will help the owner to identify target groups for subsequent development of a focused awareness raising strategy. In addition, educational programmes can be developed together with education centres to improve knowledge and understanding of relevant issues and processes, and children and teenagers may relate information to their parents. For the general public, interactive information centres providing information and education on D&ER programmes can be established.

Example

To improve the public understanding of environmental remediation of the Government of Canada's nuclear sites, an Internet site has been established where stakeholders can get updated information on the Canadian Nuclear Legacy Liabilities Program (NLLP) [18]. The site includes a section on frequently asked questions, compiled from existing project information, along with stakeholder interviews and the results of focus group discussions. This is updated on a regular basis as new questions arise. Other activities implemented as part of this programme to improve public understanding include:

- Establishment of the Chalk River Laboratories Environmental Stewardship Council, which comprises representatives from the community, municipalities, Aboriginal and First Nations groups, and from interested environmental groups;
- Establishment of the Whiteshell Laboratories Public Liaison Committee, which comprises community and municipal representatives, who meet regularly;
- News and information through community newsletters;
- News and articles published on-line[6], as well as community information bulletins;
- NLLP success stories and a series of NLLP project fact sheets as part of the web site, highlight some of the most significant completed and current projects of the NLLP.

6.2. GROUPS AND INDIVIDUALS OPPOSED TO THE PROGRAMME

Key stakeholder groups or individuals who are against the use of nuclear power on principle may have a special interest and a specific agenda during the implementation of the D&ER programmes (e.g. some political parties and non-governmental organizations). Despite the fact that D&ER projects are mainly aimed at risk reduction, there may be political benefits for some groups in hampering their implementation. These groups may decline to be engaged in the process and instead may wish to emphasize perceived negative aspects of nuclear energy in general, such as: the dangers associated with nuclear risks, uncertainty in risk determination, potential connections between decommissioning and new build and uncertainties about waste disposal routes.

6.2.1. Strategy to overcome constraint

Before starting the implementation of the D&ER programme, the facility owner should identify possible opponents (with broader interests) and approach them in a different way compared to those parties more directly concerned with project implementation. This can be done, for instance, by analysing media content related to the topic, conducting interviews with opinion leaders in the region or investigating opponents in similar programmes implemented elsewhere. An analysis of the specific concerns, values, attitudes and interests of opponents should be

[6] See http://www.nuclearlegacyprogram.ca/en/home/default.aspx

performed in order to explore the possibility of establishing contact and potential collaboration. This collaboration should start with listening to their concerns and demands, agreeing on the ground rules to establish a dialogue and, if possible, jointly framing the issue. The involvement of an independent facilitator agreed by all parties or the international community can help to open up dialogue and eventually, implement the D&ER programme. In addition, local people opposing the programme could be offered the possibility to choose their own expert or be provided with financial resources for this as a mechanism for building trust in the facility owner.

Example

Following the discovery of chemical and naturally occurring radioactive material (NORM) contamination in Olen, Belgium, a programme to remove and remediate soil from the environment around the site (e.g. river banks, streets and backyards of houses) was instigated. A district with approximately twenty houses, a school and a church were identified as being contaminated. The planned environmental remediation programme strongly influenced the daily life of the residents, for example requiring removal of gardens and top soil. In general, the level of knowledge about radioactivity and ionizing radiation among the residents was low. A group of residents did not recognize pollution as a problem and they opposed the remediation, for example on the basis that no specific problems had been experienced in the past and that such a dramatic intervention in their daily lives was unjustified. To address this constraint a working group was established with the local population (entitled Dialogue and Consultation), which was chaired by an elected representative of the local community. This group met monthly to follow the project, discussed their concerns, hosted invited lecturers and organized excursions until the environmental remediation programme was completed [19].

6.3. CONCERNS RELATED TO THE WASTE DISPOSAL ON THE SITE

Although the general aims of remediation may be supported, specific concerns may arise in which there is an intention to allow some waste to remain on-site, either in interim storage or in a specially constructed disposal facility, for example the not in my back yard (NIMBY) syndrome can occur. In the context of D&ER programmes, NIMBY is mainly associated with siting waste storage facilities. The NIMBY syndrome reflects stakeholders' concerns of having a controversial or a perceived hazardous facility constructed near to where they permanently live. A key issue here is that locals may fear that what is initially to be considered as a storage facility (i.e. temporary in nature) may become a disposal facility (i.e. a permanent solution).

6.3.1. Strategy to overcome constraint

In order to identify the NIMBY syndrome and reasons for stakeholders' perceptions, an analysis of the social and economic environment of the area should be conducted. The perception of risk could be different within different stakeholder groups and may need to be addressed separately. For these purposes, dialogue with small stakeholder groups, with a limited number of people, should be established. The long term objectives of the D&ER programme, including the expected benefits it may bring as well as the disadvantages of each option considered as part of the decision making process, should be explained to stakeholders. The work with small groups should be organized carefully by selecting an appropriate time and venue for each group of stakeholders. Establishing good communication mechanisms between the facility owner, the local authority and the public by creating special committees or councils to share their visions and concerns could also be a useful strategy to overcome NIMBY. These measures could enable the facility owner to address stakeholders' demands and concerns in a timely manner.

Example

In the case of the chemical and radiological NORM contamination at Olen, Belgium, presented in Section 6.2, one of the main problems encountered was where to dispose the waste. People living in the surrounding neighbourhood were not considered part of the process for a long period and as a consequence the environmental remediation programme could not proceed. The facility owner selected a location for the waste (close to the contaminated area) and the first stage of the remediation was completed only after appointing an independent facilitator, the Public Waste Agency of Flanders (Openbare Afvalstoffenmaatschappij voor het Vlaams Gewest, OVAM), which developed a stakeholder involvement programme. To address the NIMBY syndrome, the facilitating agency regularly communicated with all stakeholders, collaborated with schools in the neighbourhood, provided many opportunities for residents to express their concerns (e.g. public meetings and visiting residents at their homes) and developed strong relations with the local media through provision of regular information to journalists. The facilitating agency developed personal relationships with the local community, organized working groups for the residents and involved, among others, representatives of political parties in the working group [19].

6.4. DIFFERENT DEMANDS AND CONCERNS BETWEEN STAKEHOLDERS

Risk perception is the result of individual beliefs, attitudes and norms as well as of wider social and cultural aspects. In D&ER programmes, the public's perception of the risks may be broader than scientific assessments based on possible health consequences and their likelihood of occurrence, which may not be clearly communicated or understood by the public. Furthermore, different stakeholders groups have diverse perspectives and conceptualizations of risk related to D&ER programmes.

Certain stakeholders groups may make demands regarding the implementation of the D&ER programme which could be in contradiction with other groups. It is difficult for facility owners to take into consideration all demands, some of which may be technically feasible but economically unrealistic, and to assure that all positions are satisfied. In this case, some stakeholders may feel discontent about the fact that their demands were not met and may withdraw from the process.

6.4.1. Strategy to overcome constraint

A careful analysis of the opinion of the different stakeholder groups can help to reveal the differences regarding the concerns and demands coming from different quarters. Surveys, focus groups, interviews or other social science methods are useful in identifying the demands and concerns of stakeholders and how these are prioritized. Understanding the different interests, concerns and demands of the stakeholders will enable the facility owner to adapt a certain D&ER proposal in order to be more responsive or comprehensive (i.e. to embrace more of the identified concerns). Where there are multiple decision options, involving a large number of stakeholders and with high levels of interest, using a formal method of decision support (e.g. multicriteria decision analysis) can help to identify which demands are to be prioritized. In addition, the results of the analysis undertaken could be shared with stakeholder groups to encourage them to establish an overall understanding of the issue and to reach a compromise. Arranging informal events with the different stakeholders groups, providing on-site visits to the facility to be decommissioned or the site to be remediated or sharing international experience are some of the actions that promote better understanding of the issue. Satisfaction with the achieved objectives has to be checked at the end of the programme, for instance by conducting a public opinion survey.

Example

As part of the US Formerly Utilized Sites Remedial Action Program (FUSRAP) in the St. Louis area in Missouri, United States of America, different techniques were followed to understand public attitudes towards the remediation of a radioactively contaminated site which had been used for processing uranium and thorium ores. A public attitudes survey was conducted in neighbourhoods adjacent to the radioactively contaminated site with the aim:

- To ascertain levels of actual and desired public involvement in the remediation process;
- To identify health, environmental, economic and future land use concerns associated with the site;
- To solicit remediation strategy preferences.

The most highly ranked site concerns found were surface water and groundwater contamination, potential health risks and a desire for public involvement. Preferred remediation strategies included treatment of contaminated soil and excavation with off-site disposal. Among on-site remediation strategies, only institutional controls that left the site undisturbed and did not require additional excavation of materials were viewed favourably. Costs of remediation appeared to influence remediation strategy preference; however, no strategy was viewed as a panacea. Respondents were also concerned about protection of future generations, better assessment of risks to health and the environment, and avoiding generation of additional contaminated materials. Survey findings suggested three general concerns that need to be encompassed in future efforts at site remediation: decisions should be transparent, sensible and cost effective [20].

6.5. LIMITED BUDGET TO COVER STAKEHOLDERS' DEMANDS

For the implementation of D&ER programmes, some stakeholders may desire that very demanding cleanup goals are reached, for example to have a site cleaned up to background levels or at least to residual levels of contamination that are very low and go beyond national legal requirements. Although such goals may be achievable in principle, they may require excessive expenditures that go beyond the project budget, for example stakeholders may demand the adoption of a specific technique or technology (e.g. pump-and-treat instead of monitored natural attenuation of contamination). Stakeholders may also request that specific studies be conducted in order to obtain second opinions, to resolve different views or even to perform additional field measurements. Financing such studies may require additional funding, as will also be the case if more expensive technologies are applied during remediation than those originally envisaged. Where such demands are not met by the owner, whether owing to a lack of funds or disagreement about their reasonableness, the reasons need to be fully explained or stakeholders may be discouraged from future involvement, or may even begin to oppose the project.

6.5.1. Strategy to overcome constraint

The owner needs to set aside sufficient financial resources to facilitate the implementation of a meaningful stakeholder involvement programme. Clear information should be provided to stakeholders at the outset of the programme about the funds that can be made available for implementation of the project, including the basis for the amounts mentioned and limitations in spending associated with stakeholder involvement. The project budget should have margins to address reasonable propositions made by stakeholders that have not been anticipated during the planning stage (contingency). Similarly, the extent to which reasonable demands from stakeholders will be taken into consideration should be made clear beforehand. It is also important that during the implementation of the D&ER programme, regular information on the budget expenditures should be provided with the aim of acquainting stakeholders with the current situation. Negotiations between the facility owner and stakeholders are often necessary to achieve consensus related to the specific demands.

Example

The Wismut Act of 1991 limited the funds for remediation to the sites for which Wismut was responsible in 1990. This meant that no federal funding was available for a great number of sites abandoned by the then Soviet–German Corporation Wismut during the 1950s and 1960s. In addition, there was no legal requirement to take remedial actions, either by the regional government (state of Saxony) or by the landowner. After 1992, baseline studies on these sites were undertaken and the federal and regional governments agreed that environmental remediation was necessary. Following extensive negotiations between the regional and federal governments, economic resources were committed for priority sites in 2001 and for all abandoned sites in 2003. The funding for remediation is equally shared by the federal government and the state of Saxony.[7] The administrative agreement between the federal and regional governments states that at least 50% of the total budget in 2012 should be outsourced to third parties by public invitation to tender in a bid to give fresh impetus to regional development,

[7] See http://www.wismut.de/www/webroot/en/background_funding.php

for instance to overcome the constraint related to a limited budget to cover stakeholders' demands to remediate all sites, the facility owner prioritized some sites and temporarily abandoned environmental remediation plans on other sites, based on negotiation and common agreement (see also Appendix V).[8]

6.6. NEGATIVE EXPERIENCE WITH THE D&ER PROGRAMMES

The instances where implementation of D&ER programmes have failed in the past may evoke an impression among stakeholders that constraints in D&ER cannot be overcome in other projects, leading to a lack of trust. Previous negative examples from similar D&ER activities could have taken place at local, regional or even international levels and could lead to negative attitudes towards the new D&ER projects. These attitudes can be a driver or a barrier to different stakeholders to participate in involvement programmes.

6.6.1. Strategy to overcome constraint

As part of the documentation associated with the D&ER programme, it may be useful for the owner to collect negative experiences from previous relevant projects. It is important to analyse the causes and reasons for failure, identify pitfalls and difficulties. This analysis should be considered by the owner in developing the communication and stakeholder involvement activities, in case this type of information may arise during the participation processes. Additionally, information on positive experiences with D&ER projects can provide useful background information on how to implement stakeholder participation in an efficient, participatory and cost effective manner. Experience from successful similar D&ER programmes abroad may also help to overcome this constraint.

Example

One of the uranium tailing piles of the Pridniprovskiy Chemical Plant, a former uranium legacy site in Ukraine, was newly reinforced and covered in 2003–2004 (Zapadnoie tailing pile was operated between 1949 and 1954). These activities were financed by the State Remediation Programme for 2003–2005. However, insufficient funds for maintenance and monitoring of the tailing piles were envisaged by the State Remediation Programme. After a few years, the coverage of the tailings began to crack and disintegrate, resulting in increased media interest and accusations of corruption, in turn leading to widespread lack of support among the general public for further remediation activities. A more proactive approach was subsequently taken by the authorities to informing stakeholders of positive experiences with D&ER programmes in other countries, involving press releases, conducting press conferences and public hearings. The results of international expertise provided in the context of international assistance programmes at the Pridniprovskiy legacy site were also shared with the local community. Owing to such measures, the level of understanding of the importance of D&ER activities for the Pridniprovskiy site by local stakeholders increased substantially. Moreover, it has resulted in the comprehensive local support of the new State Remediation Programme in 2010–2014 and related ecological programmes for the neighbouring Dniprodzerzhinsk city.

6.7. LACK OF SUPPORT FROM NATIONAL AUTHORITIES

Governmental authorities may give low priority to the implementation of D&ER programmes in comparison to other issues (e.g. covering basic needs of the nuclear industry in maintenance and repairing services and tools for nuclear power plants in operation, spent fuel and radioactive waste management, basic needs of the people such as social payments, and food and medicine supplies). This is especially the case when the budget is limited and there has to be more focus on short term temporary solutions instead of long term sustainable ones. Furthermore, D&ER programmes may not be recognized as being directly linked to priority areas (e.g. improving the quality of life). In practice, the risks of not remediating a contaminated area can lead to intake of radionuclides within population via the food grown on these areas and a degradation of public health.

[8] See http://www.wismut.de/www/webroot/en/historic_background.php

6.7.1. Strategy to overcome constraint

Linking D&ER programmes with socioeconomic programmes may provide increased motivation among relevant authorities responsible for the implementation of D&ER programmes; such programmes may include health programmes, employment initiatives and food production. In this way, the D&ER programme may provide additional value (by improving the quality of life of the community) and should receive greater support by decision makers as well as by the local community. Advertising the benefits of D&ER activities for the given location can illustrate the possibilities of economic growth in the affected region. The attention of policy makers to the ecological problems resulting from a no-action-strategy may be enhanced by, for instance, organizing excursion tours aimed at illustrating problematic issues and thus help to gain increased commitment for programme implementation.

Example

In the immediate aftermath of the breakup of the former Soviet Union, the recovery of reactor sections of decommissioned atomic submarines from the in-water storage was a low priority issue for the Russian authorities, especially since the storage area at Sayda Bay, near Murmansk, Russian Federation, was remote and there was no suitable infrastructure for managing the waste. To implement D&ER in a rapid manner, the Group of Eight (G8) States[9] provided the resources as part of the remediation of Cold War legacy sites in the former Soviet Union to reshape the landscape and build needed buildings and extend the infrastructure to the needs of the project with local contractors. Furthermore, training of locals on the jobs for the maintenance centre and conditioning centre was an important socioeconomic driver.[10]

6.8. CHANGING THE ADMINISTRATIVE PROCEDURE AND LEGAL FRAMEWORK RELATED TO D&ER PROGRAMMES

D&ER projects may continue over several years or even decades. Consequently, legal, regulatory and financial frameworks (and also people employed by the organizations responsible for these aspects) may change during project implementation. This will lead to changes in the D&ER implementation plan that can cause an increase in needed funds, cause the schedule to slip and make it more difficult to retain qualified personnel.

Stakeholders will also change during the implementation of long projects. New people may come to live in the affected area, bringing in new ideas and demands, or older citizens may leave or die, leading to changes in community perspectives. These changes can impact the roles of the stakeholders, their possibilities for participation and can also affect how their propositions are taken into account. These changes can also affect previous arrangements in a negative way, for example by reducing their role, rights of participation and influence on the final decisions.

6.8.1. Strategy to overcome constraint

Where relevant administrative and legal frameworks related to D&ER programme change during its implementation, it is important to clearly identify these changes and how they influence the implementation of the D&ER programme and to determine the consequences for the adopted strategy of stakeholder involvement. Based on this analysis, the facility owner should explain the changes needing to be implemented in the ongoing programme and specify the new roles and responsibilities of the organizations involved and of their staff, demonstrating, where appropriate, why and how new strategies for stakeholder involvement will be applied and outlining new opportunities for participation. As a result of this transient situation, an updated plan for public participation will be necessary, which plan will have to be disseminated and further implemented.

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[9] Canada, France, Germany, Italy, Japan, Russian Federation, United Kingdom and United States of America.

[10] See
http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws092010/eng/4_4_Mietann_RW_Centre_at_Saida_Engl.pdf
http://bellona.org/news/uncategorized/2012-02-rosatom-bellona-seminar-on-global-partnership-progress-shows-signs-of-hope

Example

The former uranium mine at Žirovski Vrh, Slovenia, began operation in 1982, when the country was part of the former Yugoslavia. Uranium exploration was not continued after 1990, following the breakup of the former Yugoslavia. The closure of the uranium mine and related environmental remediation of the generated uranium tailings began under the rules of the new State of Slovenia, which became an EU member in 2004 and in turn was obliged to harmonize its legislation with EU directives. Therefore the legal framework and the administrative procedures changed several times during the implementation of environmental remediation works. The roles, responsibilities and participation possibilities changed for different stakeholders over time, and the project implementer had to address these changes. Although the existing communication and stakeholder involvement programme was limited due to financial constraints, it continued to provide information to all stakeholders, including the consequences of the above mentioned legal changes on the ongoing environmental remediation project.

6.9. LACK OF TRUST BETWEEN STAKEHOLDERS

A lack of trust between the decision makers and the various stakeholders is a significant barrier to successful D&ER programmes. Trust and credibility in certain organizations or individuals depends on the perception of the knowledge, expertise, honesty and care these individuals or organizations display in relation to the community. Effective communication requires respected and trustworthy information sources. In general, stakeholders will show greater support for D&ER programmes being implemented by organizations with high levels of trust among the local community; in the converse situation, involving low levels of trust, programmes may stagnate. It should be emphasized that building trust requires a long term engagement and is recover if lost. Furthermore, the fact that the facility owner might be a state owned company or a private company may be perceived differently by some stakeholder groups and they may show different concerns depending on who will implement the programme.

6.9.1. Strategy to overcome constraint

To overcome a lack of trust, it is important to bear in mind that this may take a long period of time. As a first step, the owner could initiate a comprehensive and concerted effort to engage the community about site issues and cleanup solutions. To achieve this, it is advisable to meet early with the community in order to respond to community concerns and to explain what actions will be taken to address their concerns. During this process, it is important to share information openly and to work with the community to involve them in decision making and data gathering. Keeping promises, admitting uncertainties and justifying the decisions taken is important for developing a responsible relationship. By linking up with trusted local officials, opinion makers or local people respected by the majority of stakeholders, it is possible to keep communication channels open. Furthermore, maintaining a presence in the community is essential to foster the whole process of trust building.

Example

For the purpose of building trust, during the decommissioning of the Vandellós I nuclear power plant, in Spain, a municipal monitoring commission was created, consisting of representatives of affected municipalities, the regional government, a local business association, trade unions, the local university, the nuclear power plant management and the organization implementing the decommissioning project. The commission had an objective to monitor the decommissioning process and to inform the local population on a regular basis. The responsible authority for decommissioning, Enresa, paid special attention to local socioeconomic issues, such as employment of local labour force providing contracts to local people or subcontracting companies at the provincial level for the dismantling activities. In addition, agreements were made with a local university on education and scholarships and there was ongoing collaboration with business associations and regional councils as part of the process to build trust with stakeholders [21, 22].

6.10. LACK OF RECOGNITION OF LINKS BETWEEN ENVIRONMENTAL, ECONOMIC AND SOCIAL CONCERNS

When planning and implementing D&ER programmes, it is important to consider national and local socioeconomic factors, infrastructure needs, cultural traditions, the role of the local community, and local challenges and demands. Environmental, economic and social aspects of D&ER programmes are interrelated and cannot be taken separately if the aim is to achieve a sustainable programme. These aspects are often not addressed in a holistic manner. For example, if the socioeconomic impacts have not been considered in the planning stage of a decommissioning programme, substantial consequences for the community may be neglected. This lack of recognition of the links between environmental, social and economic concerns in D&ER programmes may hinder the implementation of the programme itself.

6.10.1. Strategy to overcome constraint

Promoting sustainable programmes helps to overcome this constraint. Hosting a series of public dialogues designed to solicit input from local residents most likely to be directly impacted by the D&ER programmes can be effective in dealing with this issue. Integrating economic and social concerns into environmental decision making can be accomplished by forming partnerships with impacted communities and taking time to learn about community quality of life and environmental justice concerns. Both owners and regulators need to be prepared to answer questions about local economic impacts and health impacts of its environmental decisions (e.g. whether leisure activities may need to be curtailed in future in the event of a release of contaminants). Understanding the impacts can be improved by gathering a wide variety of information from local residents including demographic information, oral history of community’s health, and the location of important cultural, religious and historical sites. By integrating social, economic, and even cultural concerns of the community, trust between implementers and stakeholders can be enhanced and ultimately strengthen environmental decision making.

Example

Under the social projects of the European Commission Instrument of Nuclear Safety Cooperation Programme in Ukraine, Chernobyl Exclusion Zone, there are a large number of activities being completed and implemented with international assistance regarding the decommissioning of the Chernobyl nuclear power plant and other related activities. Radioactive contamination of the areas adjacent to the Chernobyl Exclusion Zone has resulted in health and ecological issues, affecting people living and working in these areas. Whereas technical issues were extensively addressed by both national authorities and international community, less attention was given to local livelihood conditions such as availability of medical centres, quality of drinking water and locally produced food.

As a result and using the framework of the intergovernmental agreements between Ukraine and the European Commission, the Chernobyl Exclusion Zone Administration requested the European Commission to implement various socially valuable pilot activities in the Ivankiv District, a large district in the neighbourhood of the Chernobyl Exclusion Zone. These activities include supplying medical equipment, mapping radioactive contamination, creating a news and information centre, developing and implementing of sanitary protection programmes, constructing greenhouses for production of healthy food and constructing a biomass incineration facility for contaminated woods.[11]

6.11. CONSTRAINTS THAT HINDER PROGRESS IN STAKEHOLDER INVOLVEMENT IN D&ER PROGRAMMES

A well managed participative process should lead to effective, democratic, ethical and transparent decisions. The constraints listed below represent obstacles to implementing a meaningful stakeholder participation process, which in turn may have negative consequences for overall project implementation. It is therefore important to

[11] See http://euukrainecoop.com/2013/05/07/chernobyl/

identify potential barriers to establishing meaningful stakeholder engagement and to establish strategies to overcome those barriers.

6.11.1. Absence or ineffectiveness of national policy and legal framework

In some countries, stakeholder involvement may not be included as a formal requirement in national policies and legal frameworks for implementation of D&ER programmes; others may have such requirements, but these may not be applied for reasons such as lack of resources or expertise or an absence of political will. In such situations, facility owners may be less inclined to conduct stakeholder involvement programmes. As already discussed in Section 3, it is advisable to establish a national policy for D&ER programmes which addresses all necessary legal, technical and social requirements. Such policies should also address the need to implement stakeholder involvement strategies as part of the D&ER programme.

6.11.2. Groups and individuals against the implementation of stakeholder involvement in D&ER programmes

Groups or individuals opposed to stakeholder involvement may have the capacity to challenge the implementation of D&ER programmes. This opposition may be due to reasons such as an overly technocratic, expert based approach being followed by the owner, or stakeholder groups may feel that they are unlikely to have real influence on the decisions being taken. Late recognition of the need to implement public involvement processes may present similar challenges.

6.11.3. Complexity of procedures for involvement

Stakeholder involvement is by its nature a complex process, since it entails different views, expectations and interests. In certain cases, the design of the stakeholder involvement process itself may be over complicated and could ultimately lead to confusion, delays and an inefficient public involvement process. The types of complexity could be associated with the lack of clear stages within the participation process, the absence of a clear definition of roles and responsibilities within the stakeholder involvement process, the participation methods may be too convoluted, the organization or rules for participation may not be clear, and responsibilities may be overlapping. It needs to be borne in mind that public involvement is not a straightforward process but develops in circles between stakeholders, actions and consultations. Therefore, some flexibility in planning this kind of processes is necessary and recommended. Good identification of stages in the process helps to simplify the complexity.

6.11.4. Changing opinions within one group

Stakeholder involvement is expected to be a continuous process that will take time. In some instances, stakeholders may change their opinions over a long time frame for multiple reasons. For instance, as a result of influence from other groups, the involved stakeholders may lose interest or seek a financial reward for participation. Conversely, they may become very conversant with the subject and new people may become involved in the organization with different ideas or perspectives. In addition, an external event such as an accident or an incident may have a marked impact on opinions on a specific issue.

6.11.5. Limited capacity to express opinions in public

A limited capacity to express opinions in public is often a barrier to effective stakeholder involvement, as, in many cases, participation is conducted through public meetings, where the audience is asked to express their views. Stakeholders may not be accustomed, trained or confident enough to speak in public and prefer not to express their opinions or concerns, especially if their view is in support of the owner or different from the dominant views being expressed at a particular gathering. Participants with a strong opinion against a proposal are often more vocal or trained in public speaking and therefore have a greater ability to impact and influence the audience. If some voices are not heard or not considered by other means, the stakeholder involvement process can lead to biased discussions and biased results, reflecting only a particular side of the group involved. Where the number of people in this situation is significant, they might wish to resign from the process and the overall negotiations could lose representativeness.

6.11.6. Lack of funding sources to undertake involvement

Some stakeholders will find it difficult to participate in a stakeholder involvement processes owing to the lack of financial resources required to cover such things as their time and transport to the meeting place. An absence of funding sources to compensate for their involvement may discourage participation or constrain the level and frequency of participation.

6.11.7. Limited access to information and communication

Information, reports and technical data are presented in different forms. Progress in information technology has resulted in more information being held electronically and viewed through Internet based systems, sometimes linked to Geographical Information Systems. Although this trend is generally helpful for understanding, it may create issues for those people wishing to access and review information who do not have appropriate means, for example due to lack of computers, access to the Internet or not being proficient in information technology issues. In addition, some organizations restrict the information placed in the public domain for security reasons and, therefore, access to certain information will also be limited.

6.11.8. Information overload

Information overload refers to the difficulties associated with understanding an issue caused by an excess of information. Too much information in an inappropriate form may discourage participants to effectively contribute in the stakeholder involvement process (e.g. too long and too technical reports, too many public information releases and overloading mailboxes).

6.11.9. Negative experience with stakeholder involvement

Failed stakeholder involvement processes in implementation previous D&ER programmes may result in frustration and a loss of trust in the agency or party promoting participation. Previous negative experiences may lead participants to have negative perceptions of the outcome and thus, be hesitant about participation.

6.11.10. Lack of use of independent facilitation

The involvement of an experienced neutral third party may help facilitate an effective stakeholder involvement processes in D&ER programmes. Nonetheless, owners often do not recognize the need of hiring expert facilitators at the outset to establish and maintain guidelines for conducting effective meetings, either because it may be more costly or delay the start of the D&ER programme implementation. In addition, if expert facilitators are recruited, a challenge might be that they are not recognized by all parties as neutral and are seen to support one of the parties more than the other and therefore, they are not trusted. These factors may lead to a lack of motivation to participate in the stakeholder involvement process related to a D&ER programme.

6.11.11. Lack of motivation to participate in the process

Many factors affect the motivation of stakeholders to become involved in a process for a D&ER programme. These may include a lack of trust in the promoter of the involvement process, lack of clarity regarding the responsibilities or the involvement process, unsatisfactory experiences from similar participation processes in the past, the long duration of the D&ER programmes, and lack of capacity of influence the stakeholder involvement process. There may also be a lack of awareness of the D&ER programme or the fact that some stakeholders may not perceive the issues highlighted by the owner as corresponding to the issues they see as being most important.

6.11.12. Unrealistic expectations

One of the constraints faced in a stakeholder involvement process is the high expectations from some stakeholders regarding the involvement process itself and the potential benefits (e.g. in terms of increased safety) from certain strategies being proposed by the stakeholders themselves. Where such expectations are unrealistic, and therefore are unlikely to be met, this may lead to mistrust in the D&ER programme being implemented or in the ability of stakeholder involvement process to make a meaningful impact on the final decisions taken. In these cases of unrealistic expectations, the involvement process might be truncated (e.g. where there is a deadlock situation).

6.11.13. Lack of continual stakeholder involvement and communication

As D&ER programmes are generally long term in nature, involvement needs to be sustained continuously over time throughout the entire time frame. One of the challenges encountered is to sustain stakeholders' interest and motivation and to retain their involvement over several years or even decades. The need to involve different stakeholder groups depending on the stage of the D&ER programme may also change over time, for example national authorities are likely to be more deeply involved during the planning phase than during project implementation.

6.11.14. Lack of balance between transparency and security

Achieving a balance between transparency and security considerations is often problematic as these ambitions may be in conflict. While D&ER programmes may sometimes raise important security issues (e.g. transport of radioactive material, access to nuclear infrastructure), there is also a need for transparency in public communications about the activities related to D&ER programme. Security considerations may sometimes be interpreted very broadly, and used as a pretext for not releasing project information for which security implications are minimal. As a result, stakeholders feel that relevant or negative information is being incorrectly withheld, potentially undermining trust between stakeholders and the facility owner.

6.12. SUMMARY

It is important to recognize that, in addition to policy, legal and regulatory, and technological and resource issues, societal aspects can dramatically influence the implementation of D&ER projects. In this Section relevant issues have been grouped into: (i) those which can affect the implementation of D&ER programmes directly and have to be dealt with by means of targeted stakeholder involvement plans and development of appropriate communication programmes; and (ii) those which will influence the implementation of the stakeholder involvement plans themselves therefore indirectly impact D&ER activities. Although such division has been used in this project, it has to be stressed that both groups of constraints are connected, dependent and interrelated due to the societal complexity of D&ER programmes.

Some examples of societal constraints and constraints that hinder progress in stakeholder involvement and the possible actions to be undertaken to overcome these constraints are provided in Tables 4 and 5, respectively.

TABLE 4. APPROACHES TO OVERCOMING SOCIETAL CONSTRAINTS

Constraints	Solution
Limited technical knowledge and understanding of the problem and process	Identify the existing level of knowledge and understanding related to D&ER programmes Develop a strategy for raising awareness Establish public interactive information centres Develop educational programmes with education centres Make available an overview of the D&ER projects planned to be undertaken Disseminate information material
Groups and individuals opposed to the programme	Identify possible opponents in advance Establish contact with possible opponents and listen their concerns and demands Jointly frame the problem (sharing information about the problem, diagnosing it and presenting an overall perspective) before embarking on possible solutions Agree on the ground rules to establish a dialogue Agree on an independent facilitator Involvement of the international community, where considered appropriate
Concern related to the waste disposal on-site	Reach a common understanding of the problem including stakeholders’ perceptions of risk Explain and discuss alternative approaches including not doing anything Conduct dialogue with specific stakeholders in groups limited to 15 people Carefully select the venue and time for dialogues Encourage the local community to establish working groups to interact with the facility owner Consider providing independent experts or financial resources to local communities to hire their own independent experts
Differing demands and concerns of stakeholder groups	Identify demands and concerns of stakeholders and their own prioritization (e.g. public opinion survey and focus groups) Share results within the stakeholder groups Establish an overall understanding (e.g. arrange informal events together, on-site visits and sharing international experience) Encourage stakeholders to be prepared to make compromises Check satisfaction with achieved outcomes at the end of the programme
Limited budget to cover stakeholders’ demands	Inform all the stakeholders of the budget available and its limits Provide regular information on expenditure against budget Organize negotiation between different groups of stakeholders
Negative experience with D&ER programmes	Identify and acknowledge negative past experiences Apply lessons learned from negative experiences
Lack of support by the governmental authorities to implement D&ER	Link the D&ER programme with social programmes (e.g. health programmes, employment and food production) Advertise the benefits of remediation activities at the given location Attract the attention of governmental authorities to potential ecological problems from not performing D&ER

TABLE 4. APPROACHES TO OVERCOMING SOCIETAL CONSTRAINTS (cont.)

Constraints	Solution
Changing the administrative procedure and legal framework related to D&ER programmes	Clearly identify changes and influence of these changes on the D&ER programme
	Provide public information on (new) procedures and make these available to different stakeholder groups (targeted)
	Identify (new) roles and responsibilities of stakeholders and seek their agreement and understanding
	Develop an updated plan for public participation and make it available to targeted stakeholders
Lack of trust between stakeholders	Be as transparent, dedicated, open and competent as possible
	Develop responsible relationships (e.g. keep promises and provide justifications)
	Select appropriate people to communicate that are close to stakeholders (e.g. living in the area and using the same language or dialect)
	Do not change communicators during the key process
	Listen to public concerns and address them by taking specific actions
	Admit uncertainties and problems
Lack of recognition of links between environmental, economic and social concerns	Focus on solutions that link together their environmental, economic and social concerns
	Promote sustainable programmes
	Host a series of public dialogues
	Form partnerships with impacted communities

TABLE 5. CONSTRAINTS THAT HINDER PROGRESS IN IMPLEMENTING STAKEHOLDER INVOLVEMENT IN D&ER PROGRAMMES

Constraints	Solution
Groups and individuals against the implementation of stakeholder involvement in D&ER programmes	Identify possible opponents in advance
	Establish contact with possible opponents and listen to their concerns and suggestions
	Integrate their suggestions and solutions to the stakeholder involvement plan to the extent possible
	Consider such groups separately from other stakeholders and assess the extent to which specific communication and involvement actions may be effective in engaging them in the process
Complexity of procedures for involvement	Elaborate an involvement plan that comprises well defined and short term goals
	Develop indicators to measure progress achievement
	Make clear from the beginning the different phases of the involvement process and the capacity that stakeholders may have to influence decisions in each of the phases
	Provide possibilities for feedback and improvement
Changing opinions within one group	Keep track of the opinions (e.g. record keeping)
	Encourage nomination of spokespersons for stakeholder groups who will present agreed positions
	Encourage stakeholder groups to write down and share with other groups their position so that any change in opinion needs to be well justified

TABLE 5. CONSTRAINTS THAT HINDER PROGRESS IN IMPLEMENTING STAKEHOLDER INVOLVEMENT IN D&ER PROGRAMMES (cont.)

Constraints	Solution
Limited capacity to express opinions in public	Employ trained and independent facilitators
	Use different participatory tools to encourage participation of stakeholders with limited capacity to express opinions verbally (e.g. face to face interviews and anonymous voting)
	Conduct targeted stakeholder group meetings
	Organize public speaking courses for main communicators
Lack of funding sources to undertake involvement	Make a financial plan for stakeholder involvement which requires low economic resources
	Foresee cost for subcontractors (e.g. communication companies and facilitators)
	Provide resources or incentives to cover the costs of stakeholder participation (e.g. logistics and compensation for the loss of earnings)
	Budget for communication tools (e.g. print materials, Internet and television) and use creative low cost tools
Limited access to information and communication	Provide a wide range of tools to get access to information (e.g. Internet access, newspaper and radio)
	Target information channels appropriately for the different stakeholders
	Face to face communication with workers involved in the D&ER programme is effective for passing on messages
Information overload	Provide sufficient time for processing of information
	Establish the information management system (e.g. database and search engines)
	Encourage the use of executive summaries and visual aids in reports
	Organize public speaking courses for main communicators
	Prioritize and categorize issues, from most relevant to less prone to create impacts in the decision making process
Negative experience with stakeholder involvement	Identify negative experiences with former D&ER projects at the local, regional, national and even international arenas
	Acknowledge and explain the motives and pitfalls of negative experiences
	Apply lessons learned
Lack of use of independent facilitation	Employ trained and independent facilitators
	Ensure the neutrality of the facilitator is recognized by all parties involved in the process
Lack of motivation to participate in the process	Explain the advantages of participation in the achievement of a mutual satisfactory result and the potential consequences of the absence of effective involvement
	Clarify in advance the participants' capacity to influence the decisions related to the D&ER programme
	Increase general knowledge about the problems faced
	Organize events (e.g. meetings and interviews) at convenient times and venues
Unrealistic expectations	Justify the choice of options
	Show the consequences of different options
	Share international practice and standards

TABLE 5. CONSTRAINTS THAT HINDER PROGRESS IN IMPLEMENTING STAKEHOLDER INVOLVEMENT IN D&ER PROGRAMMES (cont.)

Constraints	Solution
Lack of continual stakeholder involvement and communication	Establish mechanisms for record keeping and membership of the stakeholder group (e.g. minutes of the meetings to be issued and approved appropriately and encourage the nomination of representatives of the stakeholder group)
	Encourage representatives of stakeholder groups to disseminate the information of the activities undertaken among the members of their group
	Provide regular feedback regarding the improvements, modifications or compromises made to the process and which are the results of stakeholder involvement
Lack of balance between transparency and security	Explain the principles of transparency and security
	Establish and communicate the security and transparency policy
	Establish a security committee to coordinate the requests for information disclosure
	Develop commitment by all parties to share information in a transparent manner (e.g. through an ethics charter) and to protect sensitive and confidential information or commercial classified information which is protected from dissemination by law

7. GENERAL CONCLUSIONS

Dealing with the legacies from past nuclear and non-nuclear activities is a global concern. Principles of social justice and intergenerational equity provide fundamental justification for why Member States should undertake early decommissioning of disused nuclear facilities and environmental remediation of radioactively contaminated sites.

It is evident that many Member States face significant constraints in making progress with the implementation of D&ER programmes. This may be explained by a variety of issues:

- The absence or weakness of a national policy and framework;
- The unavailability of adequate technology and infrastructure;
- A lack of technological and human resources;
- Inadequate consideration of stakeholder involvement and political challenges.

Much can be and has been learned through detailed analysis of the constraints that have impeded greater progress towards addressing these legacies. These insights may contribute to greater progress in dealing with liabilities that currently still exist, as well as informing planners of existing and new facilities such that future liabilities are minimized.

This publication proposes a number of major strategic steps that will help to overcome those barriers and thereby will facilitate better implementation of D&ER programmes. These include:

- Implementing an appropriate legal and regulatory framework, which includes clear identification of all roles and responsibilities of those involved;
- Creating an inventory of all legacies to be considered, assessing the associated risks and possible remedial strategies and elaborate a prioritization and sequencing scheme of the projects;
- Planning projects over their whole life cycle, up to achievement of the desired end state;
- Ensuring adequate funding, which can be national or through international funding mechanisms;
- Ensuring access to competencies needed to implement projects and address the need for cultural change of operating organizations now implementing D&ER projects;

- Communicating and engaging with stakeholders throughout the planning and implementation of the programmes;
- Independently reviewing progress made and sharing international experiences;
- Adopting a graded approach in which the established framework is commensurate with the scale of the issues to be addressed.

While specific strategies have been identified to overcome the various constraints identified from a detailed analysis of the global situation of D&ER projects, it should be recognized that site specific conditions and situations may necessitate a tailored application of these strategies. Therefore, continued collaboration and knowledge sharing is critical to promoting optimal D&ER implementation worldwide.

While some progress has been made in D&ER programmes, significant opportunities exist for greater collaboration. Progressing with D&ER projects and not delaying their implementation will yield economic gains as sites and associated infrastructures are returned to useful activity, as well as improving societal confidence in the sustainability of nuclear energy.

Appendix I

OVERVIEW OF THE CIDER PROJECT AND THE GLOBAL SCOPE OF D&ER LIABILITIES

I.1. ORIGIN OF THE CIDER PROJECT

Side Events to the IAEA General Conferences in 2010, 2011 and 2012 emphasized that D&ER remains an issue in many of the IAEA Member States. At these events, the IAEA was encouraged to undertake further activities in order to better understand the global situation, and to establish mechanisms to analyse, and report on, the constraints impeding the implementation of national programmes. In response to this, the CIDER project was initiated, with the objective of contributing to the improvement of current levels of implementation of D&ER projects in the IAEA Member States. An important goal of CIDER is to raise awareness at a policy level and to promote greater cooperation among IAEA Member States dealing with the decommissioning of disused nuclear facilities and remediation of radioactively contaminated sites, and among national and international organizations involved in the different aspects of D&ER project management and fostering regulatory oversight.

I.2. SUMMARY OF CIDER SURVEY

A survey of Member States was conducted during 2012, in advance of the launch of the project to gain an understanding of the current status of D&ER programmes. A particular focus of the survey was to determine what challenges may exist that impede progress and their relative importance. Information was obtained about the following categories of facilities and sites:

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

The survey was completed by a total of 23 Member States covering together a number of about 900 facilities and sites in the categories listed above. The results confirmed that Member States have many and varied sites and installations that require D&ER and several constraints to implementing D&ER programmes were identified. These constraints are grouped below in four main categories:

(1) Absence of a national policy and framework, including:
   - An absence of national policy;
   - A lack of regulatory framework;
   - Little ownership or responsibility for legacy sites;
   - Low national priority (perceived or real);
   - Other site priorities (e.g. ongoing operations versus decommissioning activities);

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

(3) Technology and infrastructure impediments, including:
   - A lack of technology;
   - An absence of quality personnel;
   - A lack of a transport system for radioactive waste;
   - Uncertainty or unknown risks;
   - Complexity of tasks;
   - Known risk to workers;
   - Impact of and on neighbouring sites, areas and countries.

(4) Stakeholder engagement throughout the life cycle of the D&ER projects.

The survey also identified the following major factors that can promote the implementation of D&ER programmers:

— The existence of a national policy;
— The availability of regulatory requirements;
— The existence (or perception) of an imminent risk to the public or the environment;
— Stakeholder expectations and demands.

The conclusions of the survey suggest there may be significant potential benefits 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 D&ER of waste disposal sites, uranium mining and milling sites, and smaller nuclear remediation sites, shorter time frames — of the order of 15 years — may be feasible in many cases.

I.3. SCOPE OF THE PROJECT

The CIDER project is being conducted in two phases, with the first phase providing an analysis of the specific constraints impeding implementation of D&ER at different categories of radioactively contaminated installations and sites, and strategies on how these constraints might be overcome. This publication summarizes the outcomes of the first phase.

The second phase of CIDER will be focused more directly on specific situations where progress in implementing D&ER is being impaired and will outline specific actions and associated time frames to address progress constraints. The focus may include actions that are relevant at international, regional or national levels.

I.4. OVERVIEW OF GLOBAL D&ER LIABILITIES

The origin of the nuclear industry coincided with the discovery of radioactive minerals at the beginning of the 20th century — the main early activities being associated with the mining of radioactive ores for various industrial and medical purposes. Since then, land and buildings have been contaminated with radioactive residues to varying degrees and, with the advent of the nuclear weapons and nuclear power programmes, more areas have become contaminated and action is needed to reduce any levels of radioactivity having the potential to cause harm to people or the environment.

Decommissioning is concerned with activities on sites that are licensed and regulated under appropriate domestic legislation and involves the administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility or site. Decommissioning does not normally include the remediation of large land areas outside of the licensed site that are contaminated with radioactive material, being concerned only with those areas that are incidental to the operation of the facility. Environmental remediation is concerned with the removal or reduction of radiological hazards associated with contaminated land. This includes measures to reduce the radiation exposure from existing contamination of land areas through actions applied to the contamination itself (the source) or to the exposure pathways to humans.

Many modern industrial activities have resulted in areas becoming contaminated with radioactive material and, where the levels of contamination has the potential to result in exposures to radioactivity at levels that could be harmful to human beings or the environment, then remediation actions are warranted. These activities include the mining of ores and minerals, accidents from nuclear facilities, loss of regulatory control of radioactive material, production of gas and oil, military defence programmes and the production of geothermal energy. Contaminated areas may range from small areas around a particular site to large areas covering thousands of square kilometres.

The types of facility and site requiring D&ER action throughout the world include:

(a) Nuclear power plants.
(b) Research reactor facilities.
(c) Fuel cycle facilities, including:
  - Uranium processing facilities;
  - Uranium conversion and recovery facilities;
  - Enrichment facilities;
  - Fuel fabrication facilities;
  - Heavy water production facilities;
  - Fuel processing facilities;
  - Spent fuel storage facilities;
  - Associated secondary waste treatment facilities.
(d) Industrial facilities contaminated with radioactive material.
(e) Research facilities.
(f) Radioactively contaminated research and defence sites.
(g) Uranium mining and milling sites.
(h) Facilities and lands impacted by accidents.
(i) Interim waste storage facilities.
(j) Nuclear weapons test sites.

Owing to differences between the regulatory and industry framework and the types of facility and site using radioactive material, there are significant differences in the certainty of the current global situation regarding the existing inventory of facilities requiring decommissioning and the inventory of contaminated sites requiring remediation. Factors that make it difficult to compile accurate data may include:

- Reluctance of some Member States to acknowledge and formally record contaminated land areas;
- Incompleteness of characterization and mapping, especially in the NORM industry;
- Loss of regulatory control, loss of historical knowledge or records;
- Complete lack of knowledge of the existence of a contaminated site;
- Contaminated land areas are sometimes extremely large and the area boundaries may be uncertain or there may even be transboundary contamination.

Appendix II

POTENTIAL FUNDING SOURCES AND COOPERATION

This appendix discusses different potential sources of funding and cooperation for D&ER projects, addressing primary and secondary (complementary) funding along with the factors affecting the cost of the project such as availability of funds when required, cost evaluation and project implementation strategy. Whether a project is funded through primary or secondary sources, the underlying principle with regard to the distribution of liabilities is the polluter pays principle, which is universally accepted but not fully implemented in all Member States. In some Member States (e.g. Finland and Sweden), application of the polluter pays principle is enshrined in legislation.

Some of the challenges encountered in D&ER projects are:

- An absence of a policy, legal and regulatory framework regarding D&ER funding;
- Few accurate estimates of the cost of D&ER activities;
- A lack of sufficient funds to complete D&ER tasks;
- A lack of availability of funds at appropriate time;
- An absence of transparency in the use of funds dedicated to D&ER;
- Variability of parameters to be taken in D&ER funding assessment.

Appropriate actions have to be taken to overcome such issues as robust funding arrangements need to be established that address, among others:

- Availability of funds when required for project implementation;
- Cost estimation and subsequent evaluation during implementation;
- Project management, including contract management.

II.1. GENERAL CONSIDERATIONS FOR FUNDING

The cost of implementing D&ER projects generally falls on the owner of the relevant facility of contaminated site. This will not universally be true, as in some cases of early shutdown of nuclear installations through political agreements, for example the closure of some nuclear power plants in Central and Eastern Europe following accession to the European Union.

II.1.1. Ensuring the availability of the funds

Recognizing that funding arrangements used in the past were not sufficiently robust to provide adequate funds for decommissioning when needed, the UK Government requires that new power plants can only be built once it has explicitly agreed to the relevant Funded Decommissioning Programme proposed by the developer. Such schemes are likely to require that money is paid into a fund external to the company which is managed by independent trustees. Such a programme will generally incorporate an estimation of the costs of future waste and decommissioning liabilities and will demonstrate how such costs are to be financed.

In France, a regulatory framework has been adapted to include decommissioning and waste management. This is explained in Article 20 of the 2006 Act on Sustainable Management of Radioactive Waste Law (Articles L.594-1 to L.594-14 of the environment code), which lays down the obligations of licensees for financing the safe decommissioning of their installations and safe management of their spent fuel and radioactive waste. Licensees and producers of radioactive waste and spent fuel have to prudently assess the cost of decommissioning, of reprocessing or storage of spent fuel and of long term management of waste. Then, they have to establish reserves to cover that cost and to earmark dedicated assets for their exclusive coverage. Licensees and producers of radioactive waste have to submit every three years reports detailing their methods and hypothesis to evaluate this cost and reserves. These reports are reviewed by the Ministry of Energy with support from the French Nuclear

Safety Authority (Autorité de Sûreté Nucléaire, ASN), which publishes a public stance on it. If the establishment of reserves and dedicated assets is not sufficient, the Ministry of Energy may take enforcement action [23].

II.2. PRIMARY FUNDING

Primary funding should be fulfilled primarily by the owner or the country hosting the owner before access is made to complementary funding, this would follow the principle of the polluter pays. The use of complementary funding is generally relevant to situations where this principle cannot be applied, partly or fully.

II.2.1. Funding of new facilities

Funding for new privately owned is generally an owner responsibility, though there may be incentives in place by the hosting government for installations such as nuclear power plants. Arrangements such as the requirement on developers in the United Kingdom to develop a funded decommissioning programme (or equivalent arrangement) should facilitate prompt dismantling of facilities after they have been shut down.

II.2.2. Funding for legacy sites

Responsibilities for the cleanup of legacy sites generally fall on governments, with such sites often having been associated with defence programmes in the host country. Some such sites have since been privatized, sometimes leading to the situation of the site or facility being managed by a private company but owned by another organization, such as the government of the State. In the United Kingdom, a special government agency (non-departmental public body), the Nuclear Decommissioning Authority, was created through the Energy Act 2004 with responsibility to manage the civil nuclear liabilities and assets of the public sector.

II.3. COMPLEMENTARY FUNDING

Although some Member States owners have collected sufficient funds available to proceed with D&ER operations, others may not, for example those without experience of D&ER. To overcome these barriers, some international organizations provide substantial finances to help States to engage their D&ER operations (see Section II.3.1). In limited cases, bilateral cooperation between governments is organized, such as the case of the US fund for Iraqi D&ER projects.

II.3.1. Government to government cooperation

Examples of government to government funding include the arrangements established after the Second Gulf War concerning the 27 nuclear destroyed facilities and sites located in 9 locations in Iraq that were either damaged or destroyed and required decommissioning. The US and Iraqi Governments launched a cooperation programme during the period from 2008–2013 to engage in D&ER activities which included:

- Training staff;
- Providing equipment and instrumentation;
- Providing advisors for different stages of D&ER planning.

The estimated quantities of solid and liquid radioactive waste are around 1054 tonnes and 156 m^3, respectively. The expected amounts and types of the waste originating from decommissioning activities cannot be estimated at present, but most of the expected types of waste will be mainly very low or low level waste, with very limited amounts of intermediate and high level waste.

II.3.2. European Bank for Reconstruction and Development

The EBRD was founded in 1991 with a mandate to assist countries of Eastern Europe and the former Soviet Union in their transition to democracy and a market economy. It has been involved in providing international assistance in the field of nuclear safety from its inception as many of its countries of operation inherited nuclear legacies from the Soviet period.

In the context of the Group of Seven[12] (G7) Action Plan to improve nuclear safety in the countries of the Soviet bloc, presented at the 1992 summit in Munich, Germany, the EBRD was asked to establish an efficient delivery mechanism for large nuclear safety assistance programmes. The first Fund, established in response to this appeal, is the Nuclear Safety Account, which began operation in 1993. A key priority of international nuclear safety assistance has been to secure the closure of reactors of Soviet design (high-power channel-type reactors (RBMKs) as well as the water cooled, water moderated power reactor WWER 440-230) where there was a consensus that these were not upgradeable to modern safety levels. EBRD managed funds have contributed to achieving this aim in Chernobyl 1–3, Bohunice V1, Ignalina 1 and 2 and Kozloduy 1–4. The EBRD created a second fund — the Chernobyl Shelter Fund — in 1997 to fund a programme to bring Chernobyl 4 into a safe state. This was also established at the request of the international community led by the G7 States and was modelled on the Nuclear Safety Account.

A very similar approach was taken to funding the assistance programmes for the International Decommissioning Support Funds for Bohunice (BIDSF), Ignalina (IIDSF) and Kozloduy (KIDSF). Recognizing the economic burden on the three accession States posed by the agreement to close their first generation, Soviet designed nuclear power plants ahead of the expiry of their intended lifetime, the European Commission requested the EBRD to establish three funds to finance projects related to the decommissioning of these units as well as to measures in the energy sector for assisting in overcoming the consequences of the loss of generating capacity. The purpose of these funds was not to cover all costs associated with the decommissioning of the plants to be closed, as these nuclear power plants would anyway have to be decommissioned at some time in the future. The funds, which became operational in 2001, support decommissioning in recognition of the burden of early closure of these nuclear power plants. In addition, the EBRD manages a fund — the Northern Dimension Environmental Partnership Nuclear Window — which deals with the legacy issues stemming from the operation of the former Soviet Northern Fleet.

To date, 44 donor States and the European Commission have contributed over €4 billion to the EBRD managed Nuclear Safety Funds. A new multilateral Nuclear Safety Fund is being created to address the remediation of uranium mining legacy sites in Central Asia. Figure 2 shows the structure of key relationship of the parties involved in the implementation projects which are grant-financed out of EBRD managed funds.

The EBRD provides its services at cost. It does not charge any fees and makes no profit. Each year, the Fund Assemblies approve fund specific administrative budgets for the following year, although only costs actually incurred are charged to the funds. Cash held by the EBRD which is not immediately required for project purposes is placed in the EBRD's deposits and interest income from these placements is paid back to the Funds in full.

II.3.3. European Commission

The European Commission allocates part of the EU budget to companies and organizations in the form of calls for tender, grants or funds and other financing programmes. The Commission makes direct financial contributions in the form of grants to support projects or organizations, which further EU interests, or help implement an EU programme or policy. Those grants and funding are awarded by the Commission Directorate-General directly responsible for the policy area in question, by Commission offices and agencies around Europe and by other authorities (national or regional authorities, also in non-EU members).

Public bodies, including local authorities, can benefit from many EU funding opportunities, ranging from investments to develop the institutional capacity and efficiency of public services, to local infrastructure projects.

[12] Canada, France, Germany, Italy, Japan, United Kingdom and United States of America.

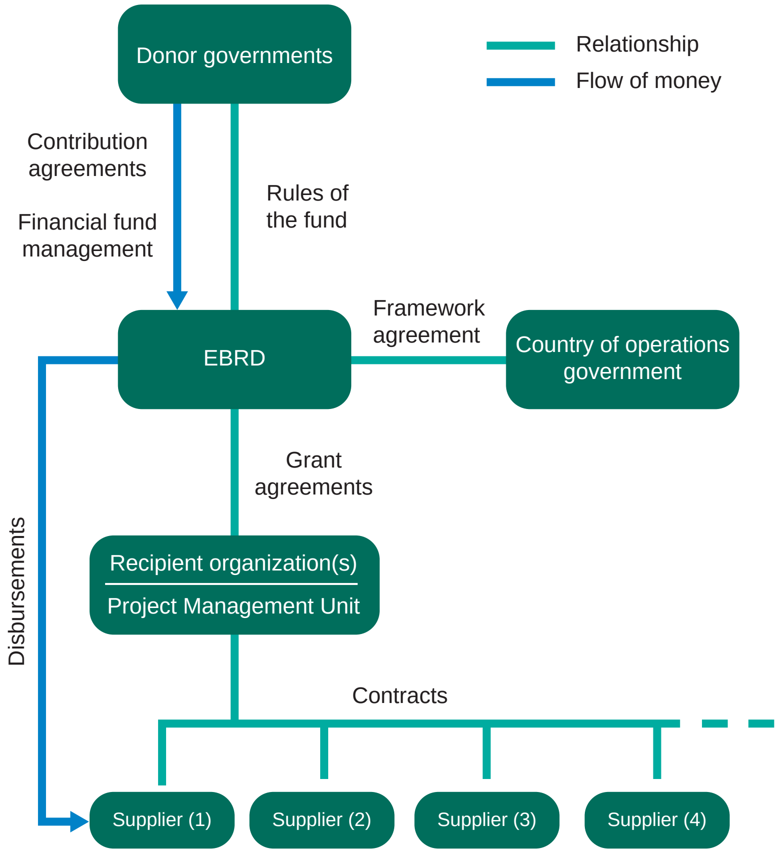

FIG. 2. Relationship of parties involved in EBRD managed international projects.

A new financing instrument for development cooperation established in December 2006 replaces the range of geographic and thematic instruments created over time and as needs arose. Geographic programmes, such as Assistance in post-crisis situations and fragile States, cover five regions: Latin America, Asia, Central Asia, the Middle East and South Africa. The Instrument for Nuclear Safety Cooperation (INSC) of the European Commission finances measures to support a higher level of nuclear safety, radiation protection and the application of efficient and effective safeguards of nuclear materials in developing countries.

The first INSC (INSC 2007–2013) came into force in 2007. Its main objectives were the strengthening of regulatory authorities, the promotion of an effective nuclear safety culture and the safe management of spent fuel and radioactive waste in non-European countries. In recent years, the INSC has substantially extended its geographical coverage, though it continues to support ongoing nuclear safety projects in the countries of the former Soviet Union. During its first phase, the INSC covered more than 20 partner countries worldwide and had a budget of €525 million for 2007 to 2013 (i.e. around €75 million per year).

The focus was on the construction of radioactive waste management infrastructure in line with European good practice. The support to the nuclear regulatory authorities and their technical support organizations has been expanding, particularly in South East Asia and Latin America. Radioactive waste management activities are under development in Central Asia, focusing on the remediation of contaminated former uranium mining sites.

In this respect, a regional project creating a legislative and regulatory framework for the remediation of uranium mining legacy sites in Central Asia was agreed upon, as well as cooperation projects with Kyrgyzstan, Tajikistan and Uzbekistan. These projects are aimed at remediating various former uranium production sites, beginning with feasibility studies and environmental impact assessments. Lastly, Mongolia benefits from an on-going project which aims to establish a regulatory framework for uranium mining and milling operations, including training.

The second INSC (2014–2020, €220 million) will continue to promote high standards of nuclear safety, radiation protection, and the application of efficient and effective safeguards of nuclear materials. The main focus of the activities during 2014–2020 is the promotion of an effective nuclear safety culture and the implementation of the highest nuclear safety standards and radiation protection, the responsible and safe management of spent fuel and radioactive waste, decommissioning and remediation of former nuclear sites and installations, and the establishment of frameworks and methodologies for the application of efficient and effective safeguards for nuclear material in developing countries.

II.4. OTHER ORGANIZATIONS THAT PROVIDE ASSISTANCE

II.4.1. North Atlantic Treaty Organization

NATO was established on 4 April 1949, with headquarters in Brussels, Belgium. It comprises 28 Member States. NATO has developed a number of partnership tools and mechanisms to support cooperation with partner States through a mix of policies, programmes, action plans and other arrangements. Among the tools developed, the partnership policy enables individual allies and partners to support security and defence related projects and build capabilities in partner States through individual trust funds. The trust funds are voluntary, nationally led and funded projects established under the framework of the NATO Partnership for Peace trust fund policy and focus on security and defence related projects.

Trust fund projects assist with the safe destruction of stockpiles of surplus and obsolete landmines, weapons and munitions. Another priority is to help to manage the consequence of defence transformation through initiatives such as the retraining of former military personnel and converting military bases to civilian use. Any partner State with an individual programme of partnership and cooperation with NATO may request assistance. A specific trust fund is then established to allow individual NATO and partner States to provide financial assistance.

NATO has provided support for assisting in the environmental security in the central Asian republics as part of their Environment and Security initiative. This initiative has assisted Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan in mitigating their environmental issues that threaten regional security. The project consisted of three phases:

(a) Characterization of source terms and determination of local contamination in selected uranium tailings sites;
(b) Radiation dose and impact assessments;
(c) Identification of appropriate mitigation and remediation countermeasures.

II.4.2. United Nations Development Programme

UNDP was established on 1 January 1966 and is the United Nations global development network, with headquarters in New York, United States of America. UNDP seeks to facilitate the sharing of knowledge, experience and resources between countries to help people to improve their lives. UNDP is funded entirely by voluntary contributions from members. The organization has country offices in 177 countries, where it works with local governments to meet development challenges and develop local capacity. In addition, UNDP works internationally to help States to achieve the Millennium Development Goals, one of which is environment and energy.

II.4.3. IAEA Technical Cooperation Programme

Through the TCP, the IAEA helps Member States to build, strengthen and maintain capacities in the safe, peaceful and secure use of nuclear technology in support of sustainable socioeconomic development. Technical cooperation projects provide expertise in fields where nuclear techniques offer advantages over other approaches, or where nuclear techniques can usefully supplement conventional means. All Member States are eligible for support, although in practice technical cooperation activities tend to focus on the needs and priorities of less developed countries.

The TCP operates in four geographic regions: Africa, Asia and the Pacific, Europe and Latin America. Within each region, it helps Member States to address their specific needs, taking into consideration existing capacities and different operational conditions. The programme aims to leverage the differences among Member States in the same region by facilitating cooperation between them. The TCP has both Member State specific and regional projects that support Member States in developing their infrastructures to plan and implement D&ER projects.

Appendix III

RESEARCH REACTORS: DECOMMISSIONING OF A SMALL REACTOR (BR3 REACTOR, BELGIUM)

Research reactors are nuclear reactors that serve primarily as source of neutrons. They are less complex than power reactors and operate at lower temperatures. Research reactors need far less fuel, and far less fission products build up as the fuel is used. On the other hand, their fuel requires more highly enriched uranium, typically up to 20% ^{235}U. More than 650 research reactors worldwide have been built or are under construction or in a planning phase; of which more than 350 have been shut down and partly or wholly decommissioned. Experience has shown that decommissioning can be undertaken in line with safety standards aimed at protecting human beings or the environment from harm, provided that decommissioning activities are undertaken in accordance with a properly formulated plan. The potential or actual radiological hazards associated with reactors may require the application of special techniques and procedures during decommissioning.

The decommissioning of the BR3 reactor in Mol, Belgium, Belgian nuclear research centre SCK•CEN, provides an example of current good practice in decommissioning research reactors.[13] Since 1991, the organization's statutory mission gives priority to research on problems of societal concern such as the safety of nuclear installations, radiation protection, safe treatment and disposal of radioactive waste, fighting against uncontrolled proliferation of fissile materials, and education and training.

BR3 was the first European pressurized water reactor (PWR) power plant and was put into service in 1962. It was in that industrial context that the BR3 has played its role as a demonstration unit for the development and improvement of decommissioning related techniques. While the BR3 power level was low (40 MW(th), 10.5 MW(e) net), it contains all the features of commercial PWR power plants. The reactor was used at the beginning of its lifetime as a training facility for future nuclear power plant operators. Later, it was also used as a test bench, in full PWR conditions, for new types of nuclear fuel (e.g. mixed oxide, consumable poison and high burnup). BR3 reached its technical end of life on 30 June 1987, after 25 years of operation.

In 1989, BR3 was selected by the European Commission as one of four pilot dismantling projects included in the third, five year EC research programme for decommissioning nuclear installations. This project began in 1989 and is ongoing [24–26].[14] The first part of the pilot project (1989–1994) involved decontaminating the primary loop and dismantling all the highly radioactive reactor internals. In 1994, an extension of the contract was signed with the European Commission, covering the dismantling of the first set of reactor internal components, which had been removed from the reactor 30 years previously. The main goal of this contract was to allow the comparison of an immediate dismantling operation with a deferred operation after a 30 year cooling period. In 1996, it was decided to carry on with the dismantling of the BR3 reactor pressure vessel (RPV), whose activity began at the end of 1997. The dismantling of the RPV was also part of a European contract. In 1999, the decontamination process called MEDOC (Metal Decontamination by Oxidation with Cerium) entered industrial service with material clearance as the main objective. The technologies used in this project are innovative, as they had not been previously implemented a similar project in Belgium.

III.1. CONSTRAINTS ON THE D&ER PROJECT

Many limitations were encountered during the BR3 decommissioning project, including:

(1) Insufficient qualified personnel;
(2) A lack of technology;
(3) An absence of a transport system and repository;

[13] See http://ec-cnd.net/eudecom/eudecomprj_br3.php
[14] See http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/Belgium/ http://science.sckcen.be/en/Facilities/BR3

(4) Working in a highly contaminated area;
(5) Impact of and on neighbouring sites, regions and countries;
(6) Known risk to workers;
(7) Uncertain or unknown risks;
(8) Long term stewardship.

It is important to take constraints into consideration when planning any D&ER activities whether the facility being decommissioned is a research reactor, a nuclear power plant, or another facility related to the use of radioactive materials or other sources of radiation.

III.2. SOLUTIONS APPLIED FOR EACH CONSTRAINT

III.2.1. Insufficient qualified personnel

Staff beginning work on the BR3 project did not have relevant significant previous experience but, through the application of appropriate methods, training, and work planning, a safe working environment was created. Over the course of the decommissioning project, SCK•CEN gained important experience which has made it a specialist in cost evaluation, strategy, study, remote cutting techniques, decontamination techniques, waste management and as low as reasonably achievable (ALARA) evaluations.

III.2.2. A lack of technology

More recent phases of the project are focused on dismantling the primary circuit and its large components. This is being accomplished using high pressure water jet cutting, which is a novel technology in Belgium.

III.2.3. An absence of a transport system and repository

Two different types of waste package were used during decommissioning: the standard 400 L drum and the standard 200 L drum. Nine shipments were made to the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (Organisme national des déchets radioactifs et des matières fissiles enrichies/Nationale instelling voor radioactief afval en verrijkte splijtstoffen, ONDRAF/NIRAS) for conditioning and then to the intermediate storage facility, including a total volume of 3.6 m^3 of high level waste. The medium level waste was manipulated with the same rack system and had a volume of 4.8 m^3. Low level waste, primarily the vessel flange and the bottom ring, had a volume of 6.8 m^3.

III.2.4. Working in a highly contaminated area

During the project, personnel worked in highly contaminated areas such as the thermal shield, Westinghouse internals and Vulcain internals. Total dose uptake of all operations is 68.1 man mSv, dose/dm^2 is 0.085 mSv/dm^2.

III.2.5. Impact of and on neighbouring sites, regions and countries

Significant levels of communication with local people and local government is essential to successful D&ER activities. SCK•CEN in Mol, Belgium, maintains strong communication with local entities while decommissioning the BR3 research reactor, including cultural and educational programmes.

III.2.6. Known risk to workers

Although dismantling tasks often involve more diverse risks to workers than those applying to maintenance and operational tasks, an effective ALARA programme has proven to be effective in ensuring that radiation protection of the workforce is optimized. The ALARA principle has been incorporated into all levels of decision making during the dismantling operations.

III.2.7. Uncertain or unknown risks

During the dismantling phase of the RPV, the team encountered two major problems:

- Some ‘non-conformities’ or discrepancies with the ‘as built’ drawings;
- Severe turbidity problems with the cutting pool.

III.2.8. Long term stewardship

ONDRAF/NIRAS and SCK•CEN run the High Activity Disposal Experimental Site (HADES) underground laboratory through the European Underground Research Infrastructure for Disposal of Nuclear Waste in Clay Environment (EURIDICE). Since 1980, this laboratory has been researching if layers of clay (such as those found in northeast Belgium) could be used for permanent storage of nuclear waste. In September 2011, ONDRAF/NIRAS fulfilled the legal obligation of publishing a national plan for radioactive waste management in Belgium.

Appendix IV

NORM FACILITIES:
NORM DECONTAMINATION FACILITY
(SYRIAN ARAB REPUBLIC)

There are a great number of industrial, mining, or manufacturing facilities globally that use or process NORM, being a substance that naturally contains one or more radioactive isotopes. NORM is present at varying concentrations in the Earth's crust. Some of the processes conducted at facilities that handle NORM concentrate one or more of the naturally occurring radionuclides, resulting in waste that contains a higher radioactive concentration than occurs naturally. This results in the requirement that the facilities be decommissioned and sites be remediated. The typical process operations for NORM generation involve the extraction, purification, filtration, smelting or pipeline transport of virtually any material of geologic origin. In general, NORM is categorized as being either 'discrete' or 'diffuse'. Discrete NORM is usually a small amount of waste material that can contains a relatively high concentration of NORM. Examples of discrete NORM include:

— Radium painted watch dials;
— Aircraft instrument panels.

Diffuse NORM is typically much lower in concentration but occurs in higher volumes of waste which need to be properly handled. Examples of diffuse NORM include:

(a) Fly ash: A fine, lightweight ash produced when coal is burned for fuel. Coal is composed mostly of carbon and carbon containing compounds, but it also naturally contains uranium, thorium and other naturally occurring radioisotopes. Because these radioisotopes are not volatile, the burning of the carbon compounds leads to higher levels of radioisotopes in the fly ash. However, not all coal contains equal levels of radioisotopes, so the level of radioactivity in the fly ash depends on the source of the coal as well as on the concentration effect of burning.
(b) Phosphogypsum: This results from the processing of phosphate ore into phosphoric acid for fertilizer. Phosphate ore naturally contains uranium and radium. These radionuclides are more concentrated in phosphogypsum because they are largely left behind when the phosphate is made into phosphoric acid.
(c) Scale deposits, sludge and produced water with isotopes from ^{232}Th and ^{238}U series concentrated and accumulated during oil production: ^{226}Ra, the predominant radionuclide, can either stay in produced water or co-precipitate with barium, forming complex sulphate compounds, carbonates and silicates. In addition, ^{210}Pb is found in considerable concentrations in the gas industry. Only minute quantities of uranium and thorium may exist in sludge and scales, owing to their relative insolubility.
(d) Other by-products or waste produced in sulphuric acid production:
    — Coal mines;
    — Smelters;
    — Refractors, abrasives and ceramics;
    — Pigment industry;
    — Thoriated welding;
    — Optical industry;
    — Glassware.
(e) NORM can be created when industrial activity increases the concentrations of natural radioactive materials or when the material is redistributed as a result of human intervention or some industrial process. It can also be the by-product or waste product of oil, gas and geothermal energy production. Sludge, drilling mud and pipe scales are examples of materials that can contain elevated levels of NORM, and the radioactive materials may be moved from site to site as equipment and materials are reused.

Activities associated with enhanced levels of NORM can contaminate the environment and pose a risk to human health. Handling, storage, transport, and the use of NORM contaminated equipment or waste media without controls can lead to the spread of NORM contamination and result in contamination of areas of land, resulting in potential exposure of the public; thus the need for NORM facilities to be decommissioned properly. The areas affected by the facilities' processes should also be remediated [27–29].

IV.1. CASE STUDY FROM THE OIL AND GAS INDUSTRY

In the Syrian Arab Republic, oil is one of the main contributors to the national economy, with a daily production of 30 900 barrels in 2010. There are six shared oil companies, with the major offshore platforms for exploration and production facilities located in the northeast. Since 1998, the Atomic Energy Commission of Syria (AECS), in cooperation with the oil and gas industry, has taken action for the treatment of NORM. This enabled the implementation of remediation projects for sludge and low level ^{226}Ra contaminated soil (originating from land farming, steam separation and landfill operations) in accordance to the Legislative Decree No. 64, Radiological and Nuclear Regulatory Office of 2007. In addition, the AECS initiated the application of re-injection water, and constructed and commissioned the NORM Decontamination Facility (NDF), which was the first in the region. To date, 60 tonnes of scales have been generated as a consequence of decontaminating the radioactive components using high pressure water jetting. The scales are kept in plastic drums and stored in an interim licensed storage at the NDF.

Although much work has been performed worldwide on the characterization and measurement of radioactive scales, limited studies have been made on the characterization of the petroleum waste from the Syrian Arab Republic, which contained mainly ^{226}Ra in scales forms, with a concentration as high as 3000 Bq/g. Resolution of this issue is likely only to be possible in the context of an international collaborative effort.

IV.2. CONSTRAINTS ON THE D&ER PROJECT

IV.2.1. A lack of historical information of NORM facilities

Facility information collected at D&ER stage may be of poor quality. Much of this is due to the age and accessibility of the facility. The information needed at this stage would be the inventory and characterization of all types of NORM (including physical form, quantity, and chemical and radiochemical contaminants). In general, little historical information exists concerning legacy contamination. Legacy contamination results from operations before the implementation of a NORM management strategy. Areas with potential legacy NORM contamination include, but are not limited to: land disposal sites, evaporation ponds, disposal pits and areas used for equipment storage, cleaning and maintenance where NORM contamination has potentially accumulated over time.

IV.2.2. Insufficient technology and qualified personnel for characterization

The level of NORM accumulation can vary substantially from one facility to another depending on geological formation, nature of operations and other factors. To determine whether or not a facility has NORM contamination, NORM surveys, sampling and analysis need to be conducted. A survey of radiological and non-radiological hazards is an initial input for the implementation of safe approach of D&ER, and it is also necessary to establish the boundary of the contamination area to be remediated. A challenging task would be to establish a comprehensive chemical and radiological characterization plan for all types of NORM contaminated waste (i.e. aqueous (co-produced and ground wastes), solid, oily sediments and equipment). The constraints are concerned with two complementary aspects: insufficient suitable technology (e.g. in situ gamma spectroscopy) and lack of qualified personnel.

IV.2.3. Uncertainties for risk assessment

The radiological risk assessment is based on the specific plan to be executed. For that purpose, all relevant exposure pathways have to be taken into account for every phase of the project, including site preparation, residues removal and cleanup, dismantling, waste handling, temporary storage, and final treatment and disposal. In addition, off-site exposure scenarios should be based on the waste management process (transport, location and type of final plant) and the end state.

IV.2.4. A lack of available decontamination methods

NORM contaminated equipment needs to be handled, transported, stored, maintained and disposed in a controlled manner. Therefore, it is critical to remove the contaminants before the equipment is transported. For example, if a drilling pipe that contains low level NORM scale is unrecognized, untreated and transported, it would cause subsequent, inadvertent exposure and spread of NORM, which would also affect its reuse or recycling. Typical decontamination methods include:

— Ultra-high pressure water jetting;
— Mechanical methods (e.g. scraping, grinding and sand blasting);
— Ultrasonic cleaning;
— Metal melting;
— Chemical methods (e.g. scale dissolution and extraction).

Unfortunately, there are almost no facilities that control NORM contaminated equipment and provide effective and efficient decontamination services. This severely hampers the decommissioning of NORM facilities in many countries.

IV.2.5. Too few disposal options for NORM

NORM from offshore oil and gas installations are generally collected and stored in metal drums or in steel containers. In many cases, short term or interim storage of these drums or containers may be required before final disposal of NORM. In general, NORM almost always includes additional hazardous components (e.g. oil, wax and heavy metals, including arsenic and mercury); therefore, it is generally difficult to adopt the final disposal options.

To provide adequate protection for both human health and the environment, it is vital to establish safe, practical and cost effective permanent disposal protocols for NORM. A permanent disposal protocol, which many States lack, should be designed to prevent contamination of natural resources such as underground water, and contamination of soil in areas that are currently remote or uninhabited but could in the future become residential or agricultural areas.

IV.2.6. Non-completion of present legal and regulatory framework

Present legal and regulatory frameworks do not cover NORM and technologically enhanced naturally occurring radioactive material (TENORM) in most States. In the United States of America, for example, NORM and TENORM were not subject to regulatory control under the Atomic Energy Act of 1954 or the Low-Level Radioactive Waste Policy Act.

IV.2.7. Liability for D&ER of legacy NORM facilities

For most legacy NORM facilities, no funds for cleanup had been allocated prior to the projects being initiated. There is also a growing concern about long term stewardship of some post-D&ER sites, which is directly related to the recognition that some contaminated sites will never be fully remediated, whether for technical, financial or political reasons.

The optimal objective is typically to return these sites to unrestricted use, which would require funds from both the government and private sectors. However, even given this optimal scenario, the question of who has the responsibility to monitor institutional controls and perform other long term stewardship activities still remains.

IV.3. SOLUTIONS APPLIED FOR EACH CONSTRAINT

IV.3.1. Historical information collection

It is critical to collect as much information as possible from the owner or the operator of the facility. If necessary, an estimation of NORM inventory is to be conducted. For example, if waste is accumulated in barrels that are reported to be half-filled, verifying the amount of waste in each barrel and counting the number of barrels would provide a more accurate inventory estimation). For legacy contamination, it is helpful to interview former staff, but a thorough characterization is indispensable.

IV.3.2. Technology and personnel training for characterization

It is necessary to provide adequate techniques and relevant equipment, such as N-type high purity germanium detector detectors. It is also critical to train the technicians via seminars, training courses and workshops (e.g. with possible support from international organizations).

Personnel who are required to monitor levels of radiation and contamination associated with NORM should be trained in the use of the instrumentation and the interpretation of the readings and measurements. There are many factors which affect the efficiency of a radiation detector and personnel who are required to monitor NORM levels should be aware of these. For example, surface coatings of water or oil and grease would attenuate any NORM contamination present on the surface and give a lower than anticipated indication on the detector. Many surfaces may be difficult to directly monitor owing to their surface condition or geometry and therefore both direct (probe measurement) and indirect (smear or swab) means of survey are required. The probe has also to be held very close to the surface to ensure optimum detection efficiency for the emitted radiation as both alpha and beta particles have relatively short range in air and gamma ray intensity will decrease in line with the inverse square law away from the source of activity.

IV.3.3. Controlling uncertainties for risk assessment

Some models and relevant computer codes (e.g. RESRAD, a code developed by Argonne National Laboratory for the United States Department of Energy) may be adopted. Representative scenarios and site specific parameter values are used to calculate dose and contaminant concentration levels. The calculations should be made on an iterative, site specific basis. Sufficient margins to account for uncertainties are usually included.

By applying the code and site specific parameters, it is possible to define an end state of D&ER which meets the relevant requirements of environmental standards.

IV.3.4. Available decontamination technology and services

High pressure water jetting (>200 MPa) is the preferred NORM decontamination method in some countries (e.g. Norway and the United Kingdom). The method works very well on easily accessible equipment and components (e.g. production tubulars). Decontaminated equipment and components will either be returned to customers for reuse, or scrapped and recycled as appropriate.

To apply this method, a mobile or stationary facility, which has substantial storage capacity to receive large parcels of contaminated equipment and components, should be established to receive NORM contaminated items from NORM producing companies and perform decontamination on a routine basis. The items may be decontaminated utilizing ultra-high pressure water jetting in a controlled environment. In this case, the entire process could be carried out in a closed loop system with no discharges to the atmosphere or water courses. The waste water from the process could be collected, filtered and recycled on a continuous basis, with the removed

NORM scale being treated and encapsulated with cement into drums for safe disposal to an authorized and engineered landfill site.

IV.3.5. Disposal options for NORM

The disposal options for NORM should be based on its categories of radioactive waste by its activity concentration. Typically, NORM is not considered radioactive waste if the activity concentration is less than 1.0 Bq/g. It should be disposed of in an approved repository (e.g. landfill) if the activity concentration is 1.0–10 Bq/g, and it should be disposed of in special repositories if it is 10 Bq/g or more.

The waste well for re-injection could be considered as a special repository, which is also the preferred method for NORM disposal, but it is usually limited to intrafield material. So, if waste wells are available, NORM (in slurry form) could be able to be injected into them. Developing an underground repository is another choice. For example, the disposal site located at Sløvåg in Sogn og Fjordane County, Norway, was opened in October 2008. The facility has the capacity (about 7000 tonnes in total) to receive all European oil and gas industry generated NORM. The procedure of disposal is as follows: containers with NORM drums are received at quayside and transported to the storage and conditioning tunnel, registered, weighed and conditioned (if necessary), then transferred to the repository tunnel, and finally grouted into concrete blocks (30–100 drums per block).

IV.3.6. Amending the legal and regulatory framework

In the absence of national regulations, some limits can be utilized that will generally ensure compliance with current international practice. For example, materials and waste media such as sludge or scale containing NORM at levels below those listed in Table 6 may be exempted from the requirements of this procedure.

TABLE 6. NORM EXCEPTION LEVELS

Radionuclide	Exemption level (Bq/g)
Ra-226	1.1
Ra-228	1.1
Pb-210	0.2
Po-210	0.2
U-238	5.5
U nat	3.0

NORM could be subject primarily to individual state radiation control regulations. For example, in the United States of America, Section 651(e) of the Energy Policy Act of 2005 gives the Nuclear Regulatory Commission jurisdiction over discrete sources of NORM by redefining the definition of source material. Therefore, NORM in Texas is regulated under the Texas Radiation Control Act.

In Norway, new legislation pertaining to the handling and storage of radioactive substances (mainly NORM) from decommissioning offshore installations came into force on 1 January 2011. The new regulation includes provisions for the handling, storage and final disposal of radioactive waste. The new regulations also specify minimum activity concentrations for the classification of waste as radioactive. For the three nuclides that are likely to be found in waste from the oil and gas industry, the limits for ^{226}Ra, ^{228}Ra and ^{210}Pb are 1.0 Bq/g. The new regulations on the applicability of the Pollution Control Act to radioactive substances include a provision requiring all waste from the oil and gas industry with an activity concentration of 10 Bq/g or more to be disposed of in special repositories.

IV.3.7. To provide funding for D&ER of NORM facilities

In Finland, the funding system works so that the licence holders submit a waste management scheme with related cost calculations and liability assessments to the government every three years. The government requests statements from regulatory bodies and from an organization that has competence in technological cost assessments. The licence holders have an opportunity to respond to the statements. The government subsequently confirms the liabilities and funding targets, and the licence holders pay appropriate contributions to the fund (or obtain repayments in the case of over payment) and provide the required securities to the state. The fund could cover the expenses of any unexpected events that might happen in the future, including the implementation of D&ER. There also some international funding mechanisms to be considered (e.g. the European Bank and UNDP).

A long term stewardship plan is set in place to assure the public that activities needed to protect public health and the environment will, in fact, be paid for and implemented even after D&ER is completed. These types of concern arise at both private and governmental sites, based on the very real possibility that sufficient technical resources may not be available long term. Government and private sector stakeholders agree that land use control is usually a governmental responsibility. However, the private sector will often provide funding for surveillance and long term stewardship in compliance with the licence of the contaminated sites.

Some of the steps associated with long term stewardship include the pumping and treatment of groundwater, and caps built to contain contaminated materials need to be monitored and maintained on a frequent basis.

Appendix V

URANIUM MINES AND MILLS: WISMUT ENVIRONMENTAL REMEDIATION PROJECT (GERMANY)

V.1. BACKGROUND AND SCOPE OF THE PROJECT

From 1946 to 1990, the Soviet–German Wismut Company produced 231 000 tonnes of uranium and became the world's fourth largest uranium producer at that time. Owing to the mining of low grade ore, about 800 million tonnes of waste rock materials, radioactive sludges and overburden material were deposited at the sites. The mining and milling activities resulted in seriously affected and devastated areas of about 10 000 km² in the federal states Saxony and Thuringia, in the former East Germany.

In 1990, after German re-unification, uranium production ceased and the German Government was faced with one of its largest ecological and economic challenges: Wismut transitioned immediately from production to decommissioning without any preparation or preplanning. Since 1991, the national corporation Wismut GmbH has been charged with decommissioning of the mines, mills and other facilities and with the rehabilitation of the sites. The German Government initially earmarked a total of €6.4 billion to remediate the uranium mining and milling legacy at the affected sites. Current estimates predict total project costs of €7 billion.

The overall project includes:

— Abandoning and flooding underground mines;
— Relocating and covering waste rock piles;
— Dewatering and geochemically stabilizing tailings management facilities;
— Demolishing structures and buildings;
— Treating contaminated water;
— Site clearance;
— Site rehabilitation.

In terms of complexity and size, the Wismut Project is unique, even by international standards. The project involves remedial activities at sites located at considerable distances away from the Wismut headquarters in Chemnitz (e.g. the Aue site is 40 km away and the Königstein site is 100 km away). Table 7 provides an overall view of the scale of the legacies left behind. Figure 3 shows the location of the different legacy sites.

TABLE 7. URANIUM PRODUCTION LEGACIES IN SAXONY AND THURINGIA TO BE REHABILITATED BY WISMUT GmbH

Sites		Schlema, Pöhla	Königstein, Gittersee	Ronnenburg	Seelingstädt, Crossen
Area (km^2)		5.7	1.4	16.7	13.1
Waste rock piles	Number	20	3	16	9
	Area (km^2)	3.7	0.4	6.0	5.3
	Volume (m^3)	47 million	4.5 million	188 million	72 million
Tailings management facilities	Number	1	3	3	7
	Area (km^2)	0.035	0.046	0.09	7.1
	Volume (m^3)	0.3 million	0.2 million	0.25 million	160 million
Mines	Number	2	2	1	1

TABLE 7. URANIUM PRODUCTION LEGACIES IN SAXONY AND THURINGIA TO BE REHABILITATED BY WISMUT GmbH (cont.)

Sites		Schlema, Pöhla	Königstein, Gittersee	Ronnenburg	Seelingstädt, Crossen
Open pits	Number	0	0	1	0
	Area (km^2)	n.a.[a]	n.a.[a]	1.6	n.a.[a]
	Volume (m^3)	n.a.[a]	n.a.[a]	84 million	n.a.[a]

[a] n.a.: not applicable.

FIG. 3. Location of the WISMUT sites.

V.2. MAJOR REMEDIAL ACTIVITIES

Major environmental impacts due to the legacies as well as rehabilitation measures aimed at their mitigation are listed in Table 8.

TABLE 8. RESIDUES, ENVIRONMENTAL IMPACTS AND KEY REHABILITATION MEASURES

Remaining facilities and residues	Environmental impacts and exposure pathways	Rehabilitation options
Underground mines	Groundwater contamination due to mine flooding	Controlled flooding including surface treatment of mine water
	Settlements, mine damages	Stabilization of near surface mine workings (backfilling)
Mine dumps	Radon exhalation; external radiation; incorporation of contaminants; contamination of water bodies	Mine dump relocation (underground and off-site); rehabilitation in situ involving regrading, covering and re-establishment of vegetation

TABLE 8. RESIDUES, ENVIRONMENTAL IMPACTS AND KEY REHABILITATION MEASURES (cont.)

Remaining facilities and residues	Environmental impacts and exposure pathways	Rehabilitation options
Worked-out open pit mine and overburdened dumps	Landscape devastation; groundwater impacts	Relocation of overburden dumps into a worked-out open pit mine, covering and re-establishment of vegetation
Tailings management facilities	Radon exhalation; external radiation; incorporation of contaminants; groundwater impacts	Dry in situ rehabilitation (removal of supernatant water; sludge stabilization using deep drains; covering; treatment of supernatant, pore and seepage waters)
Contaminated structures	Use restriction	Demolition, decontamination, salvage, safe storage of contaminated materials
Contaminated plant areas	Groundwater impacts; use restriction	Area remediation (excavation and safe storage of contaminated materials, in situ soil restoration)
Rehabilitation related LLW (e.g. water treatment residues)	Radon exhalation; external radiation	Immobilization; storage underground, in tailings pond beach areas or engineered facilities

Given different hydrological, geological and morphological conditions, as well as the different types of mining method employed, the main emphasis in decommissioning and rehabilitation operations varies from site to site.

At Aue/Pöhla, the emphasis of decommissioning and rehabilitation operations is on mine flooding and waste rock pile remediation. Waste rock piled up in and close to the town of Schlema-Alberoda (Aue site) is a source of radon emissions which may cause unacceptable effective population doses from radon and its decay products via an inhalation exposure pathway. Most waste rock piles are remediated in place. Major remediation phases include regarding of slopes, capping with a cover typically consisting of 0.8 m of inert material and an overlying layer of 0.2 m of topsoil, and then seeding for revegetation (see Fig. 4).

During flooding of the Königstein mine, aquifer protection against pollution due to former underground leaching is given top priority. To this end, Wismut conceived and implements the concept of controlled flooding with mine water being pumped to the surface for treatment.

In addition to mine flooding, rehabilitation at the Ronneburg site is focused on the relocation of more than 120 million m^3 waste rock material into the worked-out Lichtenberg open pit mine. A fleet of dump trucks — some carrying up to 136 tonnes — are being used, hauling some 40 000 m^3 of waste rock daily (see Fig. 5).

At the former uranium mill sites of Seelingstädt and Crossen, remedial operations focus on demolition of structures, surface cleanup, and tailings pond stabilization. Stabilization of tailings impoundments (removal of supernatant water, increase in shear strength by pore water removal using vertical drains, covering with geotextiles) and the covering of exposed tailings are technologically challenging tasks which are both time consuming and expensive (see Fig. 6).

FIG. 4. Coverage of waste piles in Schlema-Alberoda (Aue site).

1991

2012

2015

FIG. 5. Backfilling of the worked-out open pit mine (before and after).

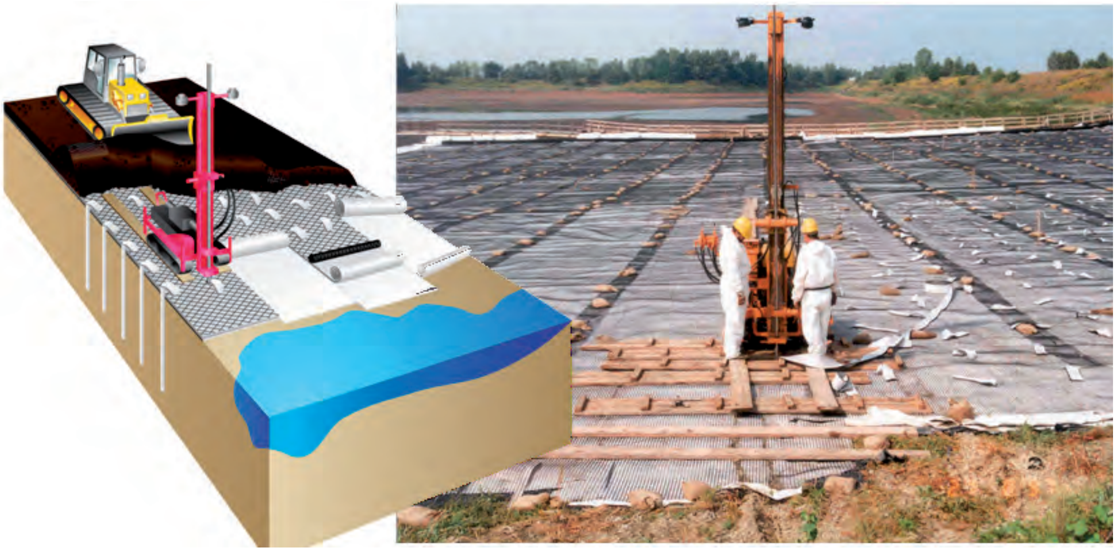

FIG. 6. Technology used to stabilize tailings impoundments, installation of vertical drains on the Trünzig tailings pond, subsite of Seelingstädt.

The Wismut environmental restoration project includes both site specific and site-spanning operations:

(a) Water treatment: State of the art water treatment plants are utilized at all Wismut sites. These plants use various techniques to remove radiological main components (^{226}Ra and uranium), as well as chemical contaminants (e.g. arsenic, iron and manganese). Feed includes mine water, seepage from mine dumps and tailings ponds, as well as water from the consolidation of tailings impoundments. Water treatment plant capacity range is 20–1050 m^3/h. Studies are underway to develop passive water treatment procedures (e.g. constructed wetlands and reactive barriers) to replace treatment plants in the long term.

(b) Waste management and residue disposal: Water treatment produces residues with specific activities of ^{226}Ra and ^{238}U in a range of 5–500 Bq/g, depending on site specific conditions. Residues generated amount to almost 30 000 tonnes annually. Specific immobilization procedures were developed for residues that are deposited in engineered areas of waste rock piles or tailings impoundments after standard immobilization processes.

(c) Besides residues, remediation and demolition produce materials with various levels of contamination, such as 350 000 m^3 of concrete and masonry debris and 260 000 tonnes of scrap metal. Depending on the level of contamination, tailor made technologies allow the separation of higher level materials for disposal or the release of lower level materials for recycling.

(d) Environmental monitoring: The remedial process is preceded by numerous studies and investigations, its implementation is monitored, and the remedial success and performance are documented and followed by long term monitoring. Monitoring is concerned with contaminants in the air, soil and water pathways, as well as geotechnical and subsidence parameters. The basic environmental monitoring programme includes the collection of 360 groundwater and 337 air quality measurement samples.

V.3. PRESENT STATE, OUTLOOK AND LONG TERM PERSPECTIVE

The Wismut rehabilitation project is currently in a mature phase. Most of the underground work has been done. Final remediation of the tailings management facilities at the Seelingstädt site involves physical work activity. This phase will be the longest lasting of the various decommissioning phases and will be completed in accordance with current plans in 2025. Concerning the sites and facilities still awaiting remediation, plans have been developed. For most sites, a consensus has been reached between Wismut and the licensing authorities regarding the viability of the proposed final remedial activities.

Following completion of the planned rehabilitation work, some long term tasks will remain. Such activities, which are expected to continue until 2040, include:

- — Water treatment;
- — Long term environmental monitoring;
- — Long term data and information management;
- — Care and maintenance of restored land;
- — Care and maintenance of ancillary mine workings;
- — Mine damage control and compensation.

It is company policy, based on consensus with all stakeholders (i.e. the owner of the company — German Federal Ministry for Economic Affairs and Energy — the authorities — State Ministries for Environmental Protection — municipalities and the local public) to put reclaimed land, and facilities and equipment to productive reuse. An example of successful integration of reclamation and town redevelopment is provided by Schlema, where recreational facilities, such as the health spa, parks, promenades and even a golf course were established on a backfilled, rehabilitated and stabilized mine subsidence area and rehabilitated waste rock piles (see Fig. 7).

FIG. 7. Aerial view towards the Schlema spa garden, with reshaped, covered, and recultivated waste rock piles on the left.

V.4. CONSTRAINTS ON THE D&ER PROJECT

V.4.1. A lack of technology

In 1991, when Wismut began rehabilitation of the sites, expertise and technology were lacking in the following fields:

(a) Stabilization of mill tailings.
(b) Cover design and cover construction for tailings ponds as well as for waste rock piles:

— To minimize water infiltration;
— To minimize radon exhalation.

(c) Efficient haulage of large amounts of waste material (e.g. relocation of waste piles).
(d) Cleanup of contaminated land.
(e) Environmentally friendly demolition technologies (e.g. blasting with low dust development, and the cutting and sorting of material).
(f) Decontamination of materials (e.g. scrap).
(g) Water treatment (e.g. mine water, seepage and pondwater).
(h) Construction of reactive walls.
(i) Treatment of organic waste (e.g. plants, timber and carbons).
(j) Phytoremediation.
(k) Treatment and immobilization of hazardous waste (solids as well as liquids) prior to disposal of the waste.
(l) Disposal of hazardous waste and organics (e.g. encapsulation, construction of technical barriers).
(m) Measurement approaches for releases of land and material from regulatory control.
(n) Monitoring approaches (e.g. groundwater sampling from deep aquifers).

V.4.2. Insufficient qualified personnel

There were two problems associated with personnel in the Wismut Project. The first issue was an overabundance of staff. At the end of the production phase, SDAG Wismut staff totalled 42 000. When remediation activities began in 1991, Wismut employed 27 800 people. Within a few years, a significant reduction in the workforce was effected to adjust the company structure to the needs of an efficient remediation company. By the end of 1992, staff numbered 6700 and was further reduced to 4600 in 1994. At the end of 2013, Wismut employed 1150 people.

Wismut also suffered from a lack of experts with backgrounds in:

— Environmental impact assessment (e.g. hydrologists, geohydrologists, geochemists, physicists and radioecologists);
— Remediation expertise (e.g. technicians, geotechnicians and environmental process technologists);
— Legal issues and real estate activities (lawyers) associated with German federal laws and frameworks;
— Management of remediation licensing according to the legal and regulatory framework of the unified Germany;
— Planning and funding of a project as large as the Wismut Environmental Remediation Project (ERP);
— Management of complex decision and licensing processes.

It should be noted that a lack of technical expertise was not the only issue: management expertise in legal issues was required to the same extent.

V.4.3. An absence of a transport system and repository

Enormous amounts of waste and soil need to be transported in a project like the Wismut EPR. For example:

(a) During the Lichtenberg open pit refilling, the waste rock piles surrounding the pit were relocated from 1991 to 2007. Altogether, 114 million m^3 of waste rock material was transported.
(b) To cover the waste piles of the refilled Lichtenberg open pit and of large tailings ponds, the haulage of inert soil from remote open pits is needed at distances exceeding 20 km. The material to be transported is in the order of several million m^3.
(c) For the relocation of the Crossen Berghalde, 3.2 million m^3 of material was transported.

Repositories are needed to dispose of the radioactive and chemotoxic materials (e.g. scrap, building debris and treatment residues) produced during decommissioning of structures and site remediation and during operation of water treatment plants.

In contrast to decommissioning and remediation projects at nuclear industry sites, uranium mining and millings sites typically include locations suitable for disposal of the waste, the envisaged disposal needs at Wismut include:

- More than 30 000 tonnes of radioactive residues and sledges from water treatment have to be disposed of annually.
- The total amount of contaminated metallic scrap arising from demolition activities is greater than 100 000 tonnes.
- The total amount of radioactive waste arising from rehabilitation of sites and awaiting final disposal is 5 million m^3.

V.4.4. Historical knowledge and characterization data: Uncertainty or unknown risks

The number of individual facilities which were subject to remediation was very high (altogether the Wismut central controlling and planning tool system lists 1457 individual facilities and subfacilities at six remediation sites). In light of this, it was very helpful that Wismut had historically emphasized record keeping of production data. From that, an overview of the facilities existed. SDAG Wismut had established a comprehensive archive of company property. Numerous data and documents were also available in archives in former East German institutions and in Soviet archives in Moscow.

However, data gaps existed regarding the characterization of the environmental impact of the legacies. Comprehensive risk estimations were not yet carried out. The main cause of this was that the conversion of Wismut from a producing organization to a remediation company occurred practically overnight. For the licensing of remedial activity, it was necessary to identify object specific risks. This required detailed facility related data (such as inventory, environmental impact data and information regarding potential land and facility use).

V.4.5. Complexity of tasks

The Wismut ERP required detailed structuring and planning, comprising:

- Six sites, up to 100 km distant from the company headquarters, in two federal states (i.e. Saxony and Thuringia);
- 1457 individual facilities and subfacilities: 48 waste rock piles, 7 tailings ponds (only at Crossen and Seelingstädt sites);
- Six mines;
- 3700 hectares industrial area.

V.4.6. Known risks to workers

Risks to workers include:

- Radiological risks; of special relevance was that many workers had experienced high doses in their early professional career at Wismut so that their working lifetime dose already exceeded 400 mSv at the time of remedial activities;
- Risk by conventional pollutants (e.g. dust and use of chemotoxic materials);
- Risks arising from physical activities (e.g. haulage of material, application of heavy machinery and thermal cutting).

V.4.7. Location of, and impact on, neighbouring sites, areas and countries

As uranium mining and milling in eastern Germany took place in densely populated areas, special remedial solutions were needed to ensure the environmental impact remained as low as reasonably achievable. Concerns include:

- Exposure to radon and dust borne, long lived alpha emitters;
- Water borne discharges;
- Noise and vibration exposure.

Cross-border problems do not exist. All water borne effluents are directed into the Germans streams in opposite direction to neighbouring countries. A challenge was (and is) communication with the local public about environment and health impacts.

V.4.8. Working in highly contaminated areas

Working in highly contaminated areas is not a significant constraint at Wismut. Uranium mining and milling waste can be classified as low level waste. Underground workplaces are the only locations where high radiation exposure may occur.

V.4.9. Long term stewardship

The business plan for the Wismut ERP is in effect until 2040. It is assumed that the physical work will finish around 2025 and will be followed by the implementation of long term activities and long term stewardship. The main tasks associated with long term stewardship are:

- Water treatment;
- Long term environmental monitoring;
- Long term data and information management;
- Care and maintenance of restored land;
- Care and maintenance of ancillary mine workings;
- Mine damage control and compensation.

V.5. SOLUTIONS APPLIED FOR EACH CONSTRAINT

V.5.1. Insufficient technology

Wismut tried to gather (and purchase) national and international expertise (e.g. by contracting outside companies or by long term contracts with consultants). In the mid 1990s, the Wismut annual budget for commissioning external engineering companies and consultants was in the order of several million euros (€9.2 million in 1995). Even now, more than twenty years after the project was launched, almost €500 000 per year are awarded by Wismut for R&D work carried out by external contractors. These funds are exclusively for research and technological development activities (i.e. funds for technical planning and routine measurements and analyses are not included).

In the early years of the Wismut Project, remediation expertise was primarily mustered from overseas (e.g. Australia, Canada and the United States of America), which also face complex legacies of uranium mining and milling. In these countries, remediation was already in an advanced state. Expertise transfer was on a commercial basis. In some cases, experts from these countries also worked for the authorities as consultants and supervisors (i.e. providing second opinions). In particular, Wismut benefitted from the expertise which was compiled during implementation of the US Uranium Mill Tailings Remediation Action (UMTRA) project. This experience was essential to start remediation of the big tailings ponds at the Ronneburg/Seelingstädt sites. From international consultants (e.g. Golder Associates or Senes Consultants), Wismut learned to structure the Wismut ERP and to develop the conceptual frame for the project.

In addition, Wismut established its own engineering capacity to perform R&D work. In the early 1990s, a team of 20–30 young scientists and engineers from universities and research institutions were hired. This team is the core of BIS (Division for Engineering and Radiation Protection). BIS, with its departments of Mine Remediation and Geo-technology, Monitoring and Radiation Protection, and with the Environmental Measurement/Laboratory Unit, consists of 120 employees. Cooperative efforts were launched with leading universities and scientific centres (e.g. the Technical University Bergakademie Freiberg, the Dresden University of Technology and the Rossendorf Research Centre). These cooperative efforts are ongoing.

In order to exchange expertise, national as well as international working groups have been established (bilateral or multilateral). An outstanding example is the Uranium Mining Remediation Exchange Group (UMREG), which was initiated in 1993 by representatives of the then German Ministry of Economy, the United States Department of Energy and Wismut. UMREG has become an important platform for information exchange, with participants from over 20 countries. Since 2012, UMREG has been facilitated by the IAEA.

The following activities served to bringing international standards and best available technologies to Wismut:

(a) Study of the relevant technical documents and guidelines issued by national and international organizations (e.g. IAEA publications, safety standards and guidelines);
(b) Expert missions, site visits and study tours to countries and organizations representing best available technologies;
(c) Implementation of workshops and seminars at Wismut (national as well as international level);
(d) Active participation in national and international conferences;
(e) Networking (e.g. via IAEA, European ALARA Network);
(f) Membership in national and international organizations (e.g. the German–Swiss Fachverband für Strahlenschtz — a radiation protection society — and the International Mine Water Association).

V.5.2. Insufficient qualified personnel

Those workers who could not find a position in the newly created Wismut GmbH were enrolled on a comprehensive training programme to prepare them for new professional careers. A special corporate structure (‘transfer society’) was established with the goal of developing and implementing training strategies to meet the regional needs of the labour market and to support the appointment of workers. Nevertheless, not for all former Wismut personnel were established in new careers. In such cases, Wismut committed to finding individual, socially acceptable solutions (e.g. early retirement with compensation).

For political reasons and the public’s mistrust of Wismut as a former polluter of the environment, it was not a matter of course to decide that former Wismut staff (including engineers and other experts) should conduct the environmental remediation programme. After careful deliberation, however, it was decided to do so, mainly to benefit from the existing local expertise (which is indispensable), but also to meet socioeconomic factors in a region which was threatened by high levels of unemployment.

Experienced managers were hired from western Germany as well as from international companies and institutions. Their expertise regarding the management of a complex project like the Wismut ERP was essential. Lawyers were also hired from western Germany.

New staff joined Wismut in the early 1990s, when scientists and engineers were hired from universities and scientific institutions (see Section V.5.1).

A comprehensive internal training programme was launched. Experts were also sent to external training courses. Wismut offers excellent opportunities for its staff members to learn best available technologies and to apply best available practices. The 2014 budget allowed €330 000 for these activities. Activities like internal and external training courses, qualifications on the job, and participation on conferences and seminars (national as well as international) are part of the programme.

Wismut operated an apprentice training unit from 1993 to 2012. Altogether, 1390 apprentices in technical and administrative professional areas graduated from this unit. The search for qualified staff is imperative to effectively manage current as well as mid and long term activities within the Wismut ERP.

It should be emphasized that while hiring and training staff is important, it is also necessary to appropriately structure departments and units to enable efficient implementation of work. The Wismut work organization reflects thereby the regional structure of the Wismut ERP (different sites, partly remote from each other and headquarters). Wismut has a process oriented internal structure, with units engaged in remediation preparation, implementation, and with controls (quality assurance and quality control, monitoring and administration).

V.5.3. An absence of a transport system and repository

For many years, Wismut operated its own lorry fleet. Large equipment was leased, and some equipment was owned by Wismut. More recently, haulage and transport capacity has been managed by external contractors. Further, Wismut operated a company owned railway unit for transporting clean soil from an open pit to the Ronneburg site. In 2014, the unit was sold to an external company.

In the special case of the relocation of the Berghalde Crossen (a radioactive waste pile), an innovative pipe conveyor transport system is in operation. This operates as a closed belt with low noise impact and no scattering of radioactive load. This special solution was necessary to relocate the 3.2 million m^3 of waste material through a densely populated area and within a nature protected river floodplain, over a distance of 1.8 km.

At Wismut, special engineered near surface facilities have been constructed to dispose of contaminated materials. Wismut uses as repositories:

— Two engineered facilities at waste rock dumps;
— Two engineered facilities in beach areas of tailings ponds;
— One engineered facility at the site of the former Lichtenberg open pit;
— One underground mine (mine gallery above the natural ground water level);
— One special landfill.

These engineered facilities include installations to mitigate the dispersion of the contaminants into the water and air path (e.g. technical barriers, drainage systems and final cover). At each facility, a monitoring programme is in operation to control the functionality of the technical barriers and drainage systems.

Important steps for the development and operation of a repository are siting, identifying optimized measures to minimize long term operation risks (including risks due to potential failure of technical barriers), completing the technical design and communicating with the public. Licensing depends on appropriate management of these activities.

V.5.4. Historical knowledge and characterization data: Uncertainty or unknown risks

Between 1991 and 1993, Wismut established its Umweltkataster (Environmental Register). The register can be understood as a huge screening programme designed to establish an environmental baseline and the basis for decision on prior remedial activities. Standardized investigations were performed on all facilities during the development of the register. Investigations included:

— Measurement of the ambient dose equivalent rate (gamma dose rate) based on grids of 20 m × 20 m (locally in a more dense grid);
— Measurement of radon concentrations (494 measuring points);
— Sampling of solids at industrial areas, at waste rock piles, at tailings ponds (one sample per 100 m^2); surface samples and samples from different depth (core drilling); analyses of radiological and non-radiological components;
— Surface contamination measurements and sampling on buildings and technical structures;
— Water sampling at existing groundwater wells, at surface and seepage water, pondwater; analyses of radiological and non-radiological components;
— Studying the hydrological and geological situation at the sites.

In total, the Umweltkataster includes 238 597 gamma dose rate data points and data from the analysis of 27 102 solid samples, 3249 water samples and 70 biota samples, respectively. Parallel to this, the Wismut baseline environmental monitoring programme was developed in the early 1990s. For this, requirements and guidelines issued by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety had to be met. The Umweltkataster results and the baseline monitoring results were fed into the Wismut environmental database (Umweltdatenbank), which was also structured and developed in the early 1990s. Beside the environmental measurements, geotechnical measurements were carried out and modern seismic monitoring systems were installed at the sites. These activities provided the general basis for risk assessment, for development of site remediation concepts, and for the identification of priority remedial activities were created.

Following the general investigation, a facility related approach was implemented. For each facility, individual measurements were taken as the basis for a facility related environmental impact assessment. The baseline monitoring was complemented by the remediation monitoring (facility related; pre-remedial, remedial and post-remedial). An important reason for these detailed investigations is that Wismut has to apply facility specific guidelines for approval of remedial actions. By now, more than 8000 individual licensing procedures were implemented, including over 1300 radiation protection related procedures.

Finally, it should be noted that for reducing uncertainties in risk estimation within the Wismut ERP, special measures are in force. For example:

- Application of a comprehensive quality assurance and quality control system, including certified lab;
- Risk assessment exclusively on base of harmonized guidelines and accepted models (e.g. guidelines for estimation of effective doses);
- Application of state of the art models (accepted by authorities).

V.5.5. Complexity of tasks

(a) Environmental and technical approach: Wismut applied a top-down approach to identify the appropriate remediation measures, consisting of:
  - Establishment of the Wismut Environmental Register (baseline investigations, screening) (see Section V.5.4);
  - Development of conceptual site models (to identify priorities and interaction of facilities and measures);
  - Development of remediation concepts for the individual sites;
  - General decisions for groups of facilities or complex facilities (e.g. standard cover on all waste piles with elevated radon exhalation; decision that all tailings ponds are remediated in situ); these ‘general decisions’ were subject to assessment by the a supervisor from the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety;
  - Facility related environmental impact assessment (present state, state during rehabilitation and post-remedial state);
  - Facility related investigations regarding justification and optimization of remedial measures;
  - Facility related design (in some cases subfacility related);
  - Facility related licensing (in some cases subfacility related).

(b) Work structure and organization: The Wismut EPR is structured with respect to the location of facilities, and with respect to the workflow:
  - Three local branches (Aue, Ronneburg and Königstein) with responsibilities for the implementation of the remedial work;
  - The headquarters with departments and units having responsibilities across all locations (general management of the project, engineering department, licensing department, human resource department, public relation department, commercial department, legal department, IT department, quality assurance and quality control department, and monitoring and radiation protection department).

(c) Administration: For the purposes of planning, controlling, record keeping, reporting, and accounting, sophisticated commercially available software solutions are in use at Wismut. The software (SAP based) was tailored to Wismut’s needs.

(d) Information technologies/databases: Wismut’s IT department is responsible for maintenance of hardware and software in the company. Different databases exist — for instance the technical database:

— Is a company owned software which has a central platform Al.VIS(W);
— Integrates individual databases (such as facility database, environmental database, licensing database, parcel database, images database, geotechnical database and database of R&D documents);
— Operation of a LIMS (Laboratory Information Management System), which manages operation of the laboratory, where actually 32 000 samples were analysed in 2013.

V.5.6. Known risks to workers

A comprehensive system of radiation protection as well as an occupational safety and health (OSH) system was established in the early 1990s, in compliance with national laws and guidelines. The challenge for Wismut was to adopt standards which were developed and applied in western Germany; the existing radiation protection and OSH framework had to be adapted to the new legal conditions. The radiation protection system includes, among others:

— Classification of occupationally exposed workers Category A (annual effective dose limit of 20 mSv) and Category B (6 mSv);
— Individual dosimetry for Category A workers; workplace measurements for Category B workers;
— Annual medical examinations of Category A workers and workers with a working lifetime dose exceeding 400 mSv;
— For each site: development and steady actualization of the Radiation Protection Regulation (annually verified by Wismut, annually approved by the radiation protection authorities);
— Remediation activity related radiation protection instructions (part of the licensing documents);
— Commitment of qualified radiation protection officers at each site;
— Existence of a company owned framework of instructions and manuals.

A similar approach has been (and will continue to be) applied to guarantee OSH, such as OSH experts at the sites are committed to protecting workers against non-radiological risks. At Wismut's headquarters, an radiation protection department and an OHS department are responsible for coordinating company activities in both fields. Radiation protection experts and safety and health experts are required to attend periodic training courses with final examinations.

At the remediation sites, measures are taken to keep risks for workers as low as reasonably achievable. For example:

— Provision of means for safe and healthy working;
— Dust depression;
— Highly developed ventilation system at underground workplaces.

V.5.7. Location of, and impact on, neighbouring sites, areas and countries

The remedial concepts and strategies developed by Wismut in the early years of the Wismut ERP considered the site specific conditions arising from nearby mining legacies and residential areas:

(a) Air pathway: radon: At the Schlema, many remedial activities are intended to manage local radon releases. All waste piles (sometimes located in residential areas) are covered. The unflooded mine workings are extensively ventilated, thus creating a permanent negative air pressure in the mine air versus outdoor atmospheric pressure. This avoids the propagation of radon towards the surface and into houses. With regard to dust and long lived alpha radioactivity, dust repressing measures are applied at all sites.
(b) Water pathway: Seepage, pond and mine waters are collected and treated. Wismut operates six powerful water treatment facilities with treatment capacities in the range of 20–1100 m^3/h. The discharge values (remaining concentrations of contaminants) are strictly regulated.

The results of the Wismut environmental monitoring programme are used to make decisions on controlled discharges. These are also used to communicate the sites' impact on the local public. All environmental data are available for public review.

It should be emphasized that Wismut's policy is to encourage stakeholder involvement. Performing remediation in densely populated areas requires remedial solutions which meet public expectations. The remedial activities conducted by Wismut are designed to complement the efforts undertaken by the communities to create viable living conditions for the inhabitants of the former mining regions.

V.5.8. Working in highly contaminated areas

Worker exposure is limited mostly by qualified ventilation systems. In 2013, due to the high level of radiation protection at Wismut, the average effective dose of Category A workers was 1.5 mSv (max. 5.9 mSv); for Category B workers, it was an average of 0.4 mSv (max. 1.5 mSv).

Wismut issues an annual report on the occupational exposure of the workers. The report is presented in the Wismut internal computer net (intranet) and is sent to the authorities. All personnel have access to their personal exposure data.

V.5.9. Long term stewardship

In structuring the work activities, Wismut distinguishes between:

(a) Remediation phase (period in which physical work is carried out).
(b) Post-remedial phase (period in which remediation success is proved):
   — The functionality of technical barriers has to be proven (e.g. investigate attenuation ability of covers and observe geotechnical settings);
   — As a rough estimate: at facilities where water borne discharges continue, a period of 30 years is considered as realistic; at facilities where radon releases continue, a period of 10–15 years is envisaged. However, the authorities will make facility specific decisions and the termination of the post-remedial period will occur when a stable state regarding acceptable releases is reached.
(c) Long term stewardship phase (water treatment, environmental monitoring, maintenance activities and real estate management).

It is currently envisaged that stewardship activities taking place until 2040 will continue to be undertaken by Wismut itself. No decisions have been taken concerning the allocation of stewardship responsibilities beyond this time frame. It is clear, however, that long term activities such as water treatment and environmental monitoring will be necessary after 2040.

Wismut is currently preparing for the long term stewardship phase. As an important part of this preparation, the company founded a data and information management centre in 2012. It provides secure storage of all relevant information about the remediation and serves as a repository of all the data and information which will be needed to perform long term stewardship tasks.

Appendix VI

DECOMMISSIONING OF FACILITIES CONTAINING DISUSED SEALED RADIOACTIVE SOURCES: RADIOISOTOPE THERMOELECTRIC GENERATORS

Orphan sources (abandoned or unused radioactive sources) need to be controlled and decommissioned to avoid unauthorized use or tampering, either of which can present a major health hazard. Orphan sources can have high levels of radioactivity, as in the case of the radioisotope thermoelectric generators (RTGs) used by the Russian Federation and the United States of America. These are safe when under supervision and treated in accordance with normal practice for the management of large sources; however, where they are not under controlled surveillance, they are liable to vandalism or theft. RTGs may often be considered orphan sources and there are similar uncertainties pertaining to the numbers and the locations [30].[15]

VI.1. CONSTRAINTS AND SOLUTIONS IN RTG FACILITY DECOMMISSIONING

RTGs are autonomous power sources that convert thermal energy from high activity isotopes into electricity. They provide long term constant electricity supply with little maintenance, and therefore are ideal for navigational purposes in locations where no electricity is provided. Their uses include power sources for spacecraft and radar.

Russia deployed over 1000 RTGs to supply constant power primarily to lighthouses and radiobeacons for navigational purposes, stretching for thousands of kilometres from the Baltic Sea to the Pacific Ocean. These RTGs use ^{90}SR for their radioactive heat sources (RHSs), with the initial RTG radioactivity in the range of 1295–17 205 TBq. Physical protection of these unattended RTGs with radioactive sources could not be accomplished at their remote locations. Moreover, with the life expectancy of these sources expiring after 2000, it was decided to remove RTGs from these sites and replace them with alternative energy sources (APSs) based primarily on solar systems. Once recovered, the RTGs were disassembled and the RHSs removed and transported to the Mayak Plant (located in the Urals) for safe, long term storage.

Joint international efforts were conducted by Canada, Finland, France, Norway, the Russian Federation, Sweden and the United States of America, and to ensure a comprehensive secure recovery, replacement, disassembly and long term storage of the radioactive sources. These States participated in the IAEA Contact Expert Group (CEG) in order to better coordinate activities in the context of the Russian Navy nuclear legacy and other, civilian, navigational activities.

As a result of the international efforts, by the end of 2014 almost all the Russian RTGs were removed from the Russian Arctic Northern Sea Route, the Far East and the Baltic Sea. A total of 482 RTGs were secured from the Russian Arctic and Far East with funds primarily from the United States of America with Canadian assistance, while Norway primarily funded the removal 180 RTGs from the Russian North West and Northern Sea Route with assistance from Canada. The Russian Federation recovered 239 RTGs. In the Baltic Sea, France, Finland, Norway and Sweden funded the removal of 87 RTGs.

The decommissioning of RTGs involve several key stages:

(1) A survey of the RTG sites;
(2) Removal of the RTGs;

[15] See:
http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/CEG/documents/Rome/English/3.10_US-RF_RTG_Decommissioning_Efforts_Eng.pdf
http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/CEG/documents/CEG-Workshop-Vienna-2013/English/2.7_Russian_RTG_program_paper_Eng.pdf
http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws042008/1_1%20Decommissioning%20Radioisotope%20Thermoelectric%20Generators%20in%20Russia%20_english.pdf
http://www.gpo.gov/fdsys/pkg/GAOREPORTS-GAO-07-580T/html/GAOREPORTS-GAO-07-580T.htm

(3) Transport of the RTGs to either an interim storage facility or to a disassembly facility;
(4) Disassembly of the RTGs and removal of the RHSs;
(5) Transport of RHSs to the Mayak plant for long term storage.

In addition, concurrent with the removal process, APS replacements are installed at most sites.

VI.2. CONSTRAINTS AND SOLUTIONS

VI.2.1. Radioisotope thermoelectric generators production

RTGs were produced in great quantities in the 1980s and mid 1990s, however, no programme was established for the decommissioning of RTGs once they reached their end of life. In 2006–2007, the Russian Kurchatov Institute in coordination with Canada and other Russian agencies created a Master Plan for the decommissioning of RTGs that included:

— RTG accounting;
— Temporary storage;
— Transport schemes;
— RTG disassembly facilities;
— Long term storage of RHSs;
— Regulatory issues;
— Environmental impact assessments;
— Risks;
— Cost analysis.

In 2007, the completed Master Plan was presented at the CEG meeting to all Member States. In 2008, an Action Plan was developed for RTG decommissioning, which included all the aforementioned phases.

VI.2.2. Accounting for, and control of, radioisotope thermoelectric generators

There was a lack of proper accounting and control of RTGs by various users in 1990s and early 2000s. A specific part of the Master Plan was devoted to collecting information from various agencies and ministries that used RTGs. This involved joint efforts to collect information and arrange expeditions to survey RTGs at the sites, and to search for lost or sunken RTGs. Consequently, a comprehensive database was developed to track RTGs and APS replacements.

VI.2.3. Radioisotope thermoelectric generator deployment

RTGs were deployed and used by various agencies and ministries, but there was no coordinator responsible for RTG decommissioning. In 2005, the Kurchatov Institute was chosen as the coordinator for the RTG decommissioning programme, while the Russian State Corporation Rosatom was responsible for the administration and supervision of the overall RTG decommissioning process.

VI.2.4. Radioisotope thermoelectric generator decommissioning programme

There was insufficient funding for the RTG decommissioning programme, as users of RTGs did not have funds for their decommissioning. International partners offered financial assistance, which significantly increased in 2002, after the launch of the Global Partnership Initiative against the Spread of Weapons and Materials of Mass Destruction.

VI.2.5. Potential donors in the decommissioning process

Potential donors to assist the Russian Federation in the decommissioning process were identified: Canada, Finland, France, Norway, Sweden and the United States of America. Moreover, the need to coordinate the international projects was also deemed necessary. Since 2005, the CEG provided a forum for the exchange of information, planning and implementing projects. Members of the CEG created a working group specifically to address RTGs. The CEG working group met biannually at the Kurchatov Institute to discuss joint activities. Norway and the United States of America were the primary donors; however, other donor States, as well as other Russian institutes, agencies and contractors, participated in the CEG working group meetings.

VI.2.6. Safe handling of radioisotope thermoelectric generator high activity sources

Safe handling of RTG high activity sources required specific technologies and facilities to be available for such handling. The infrastructure for RTG decommissioning needed to be enhanced to implement the entire programme. Technologies were developed for the extraction of radioactive sources from RTGs in hot cells and placement in transport containers. Several Russian organizations participated in the disassembly activities, including the NIITFA research institute and VO Isotope. The Kurchatov Institute (as coordinator) was instrumental in overseeing the entire process from recovery to long term storage at the Mayak Plant. Technologies were developed for the isolation of such sources at the high level waste storage facility at the Mayak Plant. This allowed for rapid implementation of the RTG decommissioning programme.

VI.2.7. Problematic radioisotope thermoelectric generators

There were some problematic RTGs with damaged casings and degraded biological protection (from corrosion of depleted uranium) not suitable for transport due to high dose rates. Some RTGs were vandalized, while others were damaged, owing to the harsh environment or normal decay. Special transport containers had to be developed for these problematic RTGs to ensure safe transport to temporary storage sites or disassembly facilities. Moreover, other RTGs were found to be problematic during the disassembly process, where it became impossible to remove the RHSs from the biological shielded inner canister owing to the swelling of depleted uranium. In this case, the RTG could only be disassembled down to the radioactive heat block, which had to be placed in a specially designed air tight canister for acceptance by the Mayak plant for long term storage.

VI.2.8. Acceptance issues

Acceptance issues existed between the rate of removals of RTGs from their remote locations and disassembly facilities. Interim storage facilities for RTGs were constructed, such as the one at the DalRAO radioactive waste management facility in the Russian Far East.

VI.2.9. Transport challenges

Transport challenges existed for the removal of RTGs from their remote sites, creating a need for safe and secure transport methods for short, medium and long distances. A normative base and licensing system was created for the safe and secure transport of RTGs. The most efficient ways and means for RTG transport were identified, such as helicopters, fixed wing aircraft, barges, hydrography vessels, special vehicles and, in some cases, rail transport. A typical example of such multifaceted logistics included removal of RTGs by helicopter from their remote locations, then loaded onto a ship and taken to the port of Murmansk, then transported by train, and finally by vehicle to the dismantling facility, where RHSs were extracted, placed in transport containers, and moved by vehicle to Mayak for long term storage.

VI.2.10. Evacuation of four radioisotope thermoelectric generators from Antarctica: A unique project

An expedition utilizing a Russian ship, with retrofits funded by the United States Department of Energy undertook the recovery of four RTGs from Antartica in 2014. Special equipment was put in place to remove one of the RTGs buried in ice within the inner continent, then transported to the coast for placement on the ship along with the other three RTGs. The mission is expected to be completed in May 2015 when all four RTGs will be repatriated back to the Russian Federation via the port of St. Petersburg.

Appendix VII

DEFENCE SITES:
EXPERIENCES FROM FRANCE, THE RUSSIAN FEDERATION AND THE UNITED STATES OF AMERICA

Defence based decommissioning problems relate largely to power plants in submarines and the decommissioning of fuel facilities. Since the practice of dumping nuclear reactors in the sea was internationally agreed to be environmentally unsound in 1993, the construction of well structured, effective mechanisms for disposing of military nuclear waste has been necessary. However, this has raised some additional hurdles besides the more common problems faced by civil waste management.

Military programmes are impacted by a number of factors concerning interim storage facilities, submarine storage and over classification issues. These can cause sufficient problems to slow or halt a process aimed at minimizing the potential environmental hazards of radioactive wastes as well as the security threats which may also be involved if these facilities are not decommissioned properly.

A resultant problem of military programmes is the secret nature of the reactors, owing to competition between different designs and the need to keep information concerning the performance of the vehicles highly confidential. This can create problems where off-the-shelf components are often over classified; that is, with information being classified as restricted or confidential even in the case of equipment whose role does not contribute to the critical abilities of the vessel, such as a backup diesel generator. This can cause problems with decommissioning as the regulatory framework will obstruct otherwise menial tasks, which could have been easily avoided if the correct classification levels had been applied at design.

The US programme has been largely able to find disposal routes for its own defence nuclear waste. This waste is stored at the Waste Isolation Pilot Plant and the reactor compartments are stored in Hanford. The main advantages over other States (e.g. the Russian Federation and the United Kingdom) are the finances allocated to the programme, as well as the vast land resources available for disposal (dry, remote places allow for easier and more effective security measures) [31, 32].[16]

Different States follow slightly different strategies depending on their circumstances:

(a) US strategy:
- Remove weapons prior to arrival;
- Remove loose material and equipment, drain gas and fluid systems, and deactivate other systems;
- Dry dock ship and defuel. Drain primary circuit fluids;
- Cut the reactor compartment, seal and place it on a barge;
- Tow barge with reactor compartment to storage facility;
- Dispose of the remaining parts in a conventional manner.

(b) French strategy:
- Remove fuel;
- Isolate reactor compartment and strip and drain compartment;
- Seal the reactor compartment and cut it out of the submarine;
- Remove any other radioactive components and then proceed with conventional submarine decommissioning.

The original Russian strategy has faced several constraints, which resulted in a need for revision, due to differences in climate and coastal geography. The Russian submarine decommissioning programme has been assisted by several States, coordinated by the CEG, facilitated by the IAEA until 2015 to assist the dissolution of the accumulated Cold War legacy comprising nuclear fuel, radioactive waste, and 200 nuclear powered submarines and surface ships. With this international assistance, the CEG has coordinated the completion of Russian

[16] See http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/documents/ws032003_vasiliev-e.pdf

decommissioning activities quite successfully, with 4 of the 200 submarines requiring dismantling in the Far East. The last legacy submarine is being dismantled in 2014 in the northwest and 54 of the 120 legacy submarines from the northwest are in storage in the new facility in Sayda Bay, Russian Federation, in a building funded by Germany. There is another storage facility in Cape Ustrichni to store the reactor units in the Far East with its own decommissioning blast and paint facilities being funded by Japan.

VII.1. CONSTRAINTS AND SOLUTIONS ON THE D&ER PROJECT

VII.1.1. An absence of a repository

Defence spent nuclear fuel usually requires a separate repository, as it is enriched to higher levels ($^{235}U \geq 10\%$) than fuel used in commercial reactors, which requires greater security than civil spent nuclear fuel. It is far more likely that the spent fuel will be processed at a later date, this option being restricted to States which have reprocessing facilities, though these tend to be the States which will have such highly enriched fuel in the first place.

The United States of America does not reprocess its submarine spent fuel, which strategy is aided by the ready availability of ‘fresh’ fuel, which is in surplus given the dismantling of nuclear arsenals and the ore available from uranium mines, thus reducing the economic feasibility of reprocessing.

As a short term solution, the United Kingdom has kept all the submarine fuel assemblies stored intact and have deferred dismantling until a repository can be agreed on and developed by the UK Department of Energy and Climate Change. The current options being considered are to remove and dispose of the reactor compartment and the RPV, or to remove the RPV and then to dispose of it as packaged waste.

The Russian Federation and the United States of America follow a general strategy of cutting out the RPV section of the submarines and storing them in large near surface repositories. The approach involves the removal and storage of the fuel, removal of the reactor compartment, followed by the dismantling of non-radioactive components in a conventional manner.

Germany has provided assistance as part of CEG in the construction of the facility for long term storage of reactor components at Sayda Bay, Russian Federation. This facility consists of a large concrete pad with a network of rails to transfer and store 150 reactor compartments for submarines and 25 compartments for surface ships and maintenance ships. There are also many support facilities constructed in the same area to aid dismantlement of submarine and ship compartments, for which the total estimated cost is US $36 million at current price levels.

VII.1.2. Complexity of tasks

Many military vessels are prototypes or exotic designs which require specialist knowledge and the ability to adapt current frameworks for their successful dismantling and decommissioning (i.e. liquid metal reactors — K-27 and Alfa class, and Russian submarines).

The first reactor with liquid metal coolant (Reactor 900) was safely defuelled in the CEG programme and its spent nuclear fuel removed from Gremikha Bay, Russian Federation, as of 2013. The defuelling of Reactor 910 was then undertaken, both projects being a result of joint cooperation between France and the Russian Federation. Italy undertook the manufacture of ten TUK-143 casks for storage and transport of the reactor cores with liquid metal coolant (of Alfa class nuclear power plant) for delivery to Russia (in 2014). The United States of America has funded the modification of the TUK-108 casks for the storage of fuel from the reactor cores and their transport from Gremikha Bay to Mayak Bay.

Appendix VIII

POWER REACTORS

Decommissioning of nuclear facilities in many countries has evolved into a mature industry that has benefited from experience gained from previous projects and decommissioning costs can now be estimated to a good degree of accuracy. As a result of lessons learned, future decommissioning projects can be performed with higher levels of efficiency.

Decommissioning of old power reactors is in progress in several countries. In some cases, decommissioning has been completed (i.e. plant sites have been released from regulatory control), while in other countries decommissioning is still in progress. Several large power reactors have been successfully decommissioned since 1995 [33–37].

VIII.1. CONSTRAINTS AND SOLUTIONS ON THE D&ER PROJECT

VIII.1.1. Insufficient technology

The key areas of particular importance for decommissioning are decontamination, radiation protection, dismantling and demolition. The technologies which can be used for these tasks are commonly available on the market, but effective decommissioning still depends on an optimal choice of technologies, including site specific developments. It is not possible to recommend the use of a single specific technology for dismantling, demolition, segmentation or decontamination; rather, it is good practice to take into account as much information as possible from other decommissioning projects and to draw comparisons between various techniques in order to choose the one with the best performance in a particular situation.

The exchange of information on all types of decommissioning experience, including decommissioning techniques and their applicability as well as disadvantages for specific tasks, is taking place on various levels, such as:

- Collaborative working groups established by international organizations such as the IAEA, the OECD Nuclear Energy Agency and the European Commission and the publication of technical reports by such organizations;
- National and international conferences;
- Bilateral or multilateral cooperation and information exchange between organizations with responsibilities for decommissioning in their respective countries.

VIII.1.2. Insufficient qualified staff

The transition from operation to decommissioning and the decommissioning strategy will have a major effect on the number of personnel employed in the nuclear installation. There will be a decrease in the number of staff at the end of the operational phase (sometimes this will take place after the decision to shut down the plant has been disclosed to the staff); however, the number of staff will increase again when active dismantling begins. During dismantling, the work may be carried out by contractors, so different personnel may be involved than those employed during the operational phase.

In cases of deferred dismantling, the situation may arise that no staff from the operational phase with adequate plant configuration knowledge are available to be contacted, making it necessary to give special attention to how plant knowledge and requisite skills will be retained over the long term.

The period before the final shutdown until the end of the transition to decommissioning stage is used by the licensee to plan and implement programmes for key staff management directed to mitigate the negative consequences of plant shutdown (e.g. loss of qualified staff with plant relevant knowledge).

VIII.1.3. A lack of historical knowledge, characterization data and uncertainties

Past history of the site has to be reviewed. Documentation that lays out the purpose, function and events associated with the site should be gathered, and personnel present during prior operations at the site should be interviewed. Data gaps should be addressed.

Radiological characterization plays an important role in decommissioning as the basis for radiation protection, identification of contamination, assessment of potential risks, cost estimation, planning and implementation of decommissioning. At all stages of a decommissioning project, adequate radiological characterization is of crucial importance. Characterization is a continuous process. It is conducted to understand health and safety concerns for workers, protect human health and the environment, understand the nature and extent of contamination, and anticipate the disposition of waste.

Insufficient characterization data lead to higher cost estimate uncertainty. Determining the true nature and extent of radiological and non-radiological contamination is an important prerequisite for defining the scope of a decommissioning project. From a risk management perspective, accurate characterization data are more important in determining the scope of a project than any other activity that the project staff can control. Failure to properly characterize a facility can lead to poor decisions on cost and schedule, decontamination strategy and the final status survey. For example, experience gained during the decommissioning of the Yankee Rowe nuclear power plant demonstrated that non-conservative assumptions based on inadequate characterization data leads to the underestimation of the actual quantity of contaminated concrete and soil. In hindsight, it became evident in this case that, had the true nature and extent of all of the radiological and non-radiological contamination been identified, overall decontamination strategies would have been more aggressive.

Subsurface radiological characterization merits special attention, this being an important issue mainly for nuclear power plants and fuel cycle facilities where during a long operational period, where leakages have occurred and contamination has spread in environmental media. In such cases, very extensive knowledge of the radiological situation from a limited amount of data has to be derived.

The facility operator needs to assess and take into account the uncertainties of characterization data in decommissioning planning and implementation, in order to provide appropriate contingency arrangements for the identified uncertainties, for example with regard to:

— The ability to retrieve, characterize, sort, segregate, categorize, treat, store and dispose of wastes;
— The development or provision of new treatment facilities or processes required to convert decommissioning wastes into forms suitable for long term storage or disposal;
— The availability of on-site discharge or burial options;
— The availability of off-site disposal sites.

VIII.1.3.1. Site characterization example

Based upon site characterization, Connecticut Yankee installed groundwater monitoring wells in various areas of the site and began groundwater monitoring in late 1997. The results of these early samples showed significant levels of tritium in the plant’s industrial area. This was consistent with the draining of a tank that was suspected to leak. An expanded monitoring plan that began in 2001 included analysis of groundwater samples of concern identified as potentially present at the Connecticut Yankee site. Strontium-90 had existed at some locations on the site and this contaminant entered the groundwater table during periods of high water. It was postulated that as the water table rose, it came in contact with contaminated soil and would result in the dissolution of the ^{90}Sr from the soil owing to the chemical equilibrium of water and soil. The mobilized ^{90}Sr would then move through the groundwater and be detected in the samples taken from wells downgradient of the contaminated soil inventory.

To provide further definition, an extensive soil characterization programme was initiated. The results of this campaign indicated that the highest levels of radionuclides were present under the tank farm adjacent to the auxiliary building.

VIII.1.4. Known risks to workers

The protection of workers against radiation exposure is a critical aspect of decommissioning and usually dominates concern. It is important to keep in mind that the broad range of activities involved in decommissioning a nuclear facility includes a host of risks that are non-radiological in nature, and such risks are covered by OSH regulations. It is generally accepted that the radiological hazards associated with a nuclear facility undergoing decommissioning are substantially less than those that existed when it was in its operating state. Even so, it is also clear that decommissioning activities, which tend to involve a set of contractors and workers who are new to the facility and operating in a temporary mode, bring risks that were not planned for in the course of routine operations.

The number of safety and health protection issues that needs to be considered in decommissioning implementation is extensive and should be adequately addressed by careful and systematic planning.

VIII.1.5. An absence of a repository

Management of radioactive waste arising from dismantling activities, including clearance of certain materials from regulatory control (in States where this option is envisaged in relevant national legislation) is a key component for decommissioning projects. The availability of appropriate facilities for interim storage and/or for final disposal, and the associated legal framework for waste management, are important considerations when deciding on the decommissioning strategy. Such examples include:

(a) France: As for other States with nuclear power programmes, there is currently no disposal route for high level waste, and it is for the time being stored in the nuclear installations. EDF is planning a centralized interim storage (ICEDA — activated waste packaging and storage installation) for this type of waste pending the availability of an appropriate disposal facility.
(b) Germany: As no disposal facilities for radioactive waste are available, a number of decommissioning projects are converting or have converted a suitable building into an interim storage area or have constructed a new interim storage building for radioactive waste (e.g. Greifswald, Niederaichbach, Großwelzheim and Kahl). The availability of a repository for radioactive waste which might be expected in 10–20 years might help to avoid costs for interim storage of radioactive waste in dedicated buildings.
(c) Italy: Four nuclear power plants have been shut down in the wake of the Chernobyl accident and are waiting decommissioning. No repository is available; storage capacities for radioactive waste are currently enlarged.
(d) Netherlands: The Dodewaard nuclear power plant has been shut down and has been brought into safe enclosure after minor dismantling, with a planned duration of 40 years. While central waste storage capacities are available, no repository exists.
(e) United States of America: In 2007, the United States Nuclear Regulatory Commission declared the decommissioning of Yankee Rowe complete. Spent fuel assemblies are still on-site, contained in dry casks. These will be located at the site until the United States Department of Energy has completed a future federal disposal facility for spent nuclear fuel.

VIII.1.5.1. Adoption of bulk removal approach

The availability of the Envirocare (now EnergySolutions) disposal facility in Clive, Utah, from the mid 1990s reduced waste disposal rates and modified decommissioning from a time consuming and costly on-site decontamination with a subsequent final status survey approach, to a more aggressive approach of shipping contaminated material off-site for disposal. The availability of a cost effective off-site disposal option for contaminated materials has resulted in shorter decommissioning project schedules.

(a) This bulk removal approach has allowed for the reduction of final survey costs. Complete removal of structures as assumed radioactive waste has been found to be much less expensive than the time and labour intensive process of performing final status surveys.
(b) The use of bulk demolition techniques reduces project durations and labour costs.

(c) The use of large, reusable waste shipping containers has allowed for bulk removal, packaging, and disposal of contaminated soil and rubble. Decreased packaging and material handling costs have been demonstrated using this method. In addition, this approach is likely to accelerate the rate at which decommissioning work can be accomplished.

VIII.1.6. Social and environmental aspects

Three main situations can be distinguished:

(1) High impact on the local economy: Cases where a nuclear installation was the main employer in an area during its operation usually have a significant economic impact. Such areas are often remote with poor infrastructure, away from larger cities or centres of commerce. Consideration of impact on the local economy and preservation of jobs may promote immediate dismantling as the preferred strategy.
(2) Medium impact on the local economy: In cases where a nuclear installation is one of several major employers or where a decommissioning strategy is chosen which preserves a large number of jobs, the impact on the local economy may be moderate. One reason for choosing the early decommissioning option is to retain as many employees as possible.
(3) Low impact on the local economy: In cases where the nuclear facility is situated in an economically prosperous area or where it is part of a multifacility site, the impact on the local economy of taking that facility out of operation is generally small. Employees may find employment in the same area in related activities, for example as is likely to be the case at Barsebäck nuclear power plant (Sweden) and Stade nuclear power plant (Germany).

Some of the German nuclear facilities are located in sparsely populated regions within the borders of small communities and are often the major source of employment and public income in the region. The community and local business are highly dependent on such facilities. The closing down of a nuclear facility and the decommissioning to ‘green field’ conditions are major changes and are associated with a great deal of social impacts. In order to attenuate such impacts, immediate dismantling will help to keep many of the staff employed and the local suppliers in business. In the long term, political and economic skills are required to find replacements for the nuclear industry and the associated jobs. Such an approach is, for example, taken in the case of the Greifswald nuclear power plant, which is located in an economically depressed area. Other nuclear facilities, such as the Stade nuclear power plant, are located in areas with a high demand of skilled personnel. In such regions, it is generally not a major issue for former employees to find new job opportunities.

VIII.1.7. Working in highly contaminated areas

Industrial safety issues are usually adequately covered according to the national regulations. The specific additional safety aspects which are posed by decommissioning activities performed in contaminated areas have to be adequately addressed, for example:

— Employ specific protective equipment, including remote controlled mechanisms, which in the decommissioning projects are usually further developed to meet the requirements of the workforce in that particular environment;
— Use mock-ups to train personnel in a ‘cold’ environment for the specific work they will later perform in real conditions.

The skills of the personnel required to cope with new tasks in the course of decommissioning have to be constantly improved by providing training specific to working in highly contaminated environments. The use of experienced contractors may be a good option in these cases.

Appendix IX

SOCIETAL INVOLVEMENT EXAMPLES FROM SELECTED MEMBER STATES

Stakeholder involvement is commonly undertaken as an integral part of the environmental impact assessment process that itself takes place prior to, or as part of, a licensing process.

IX.1. STAKEHOLDER INVOLVEMENT IN GERMANY

IX.1.1. Overview of stakeholder involvement and constraints

In general, the number of objections to granting decommissioning licences is much fewer than those against the licensing of new nuclear facilities though, as the most recent commissioning of a newly built nuclear power plant in Germany was in the late 1980s, comparison is only meaningful with licensing of new interim storage facilities, final disposal sites, research reactors and the licensing processes of decommissioning of a nuclear power plant.

The number of different objections against a decommissioning licence in Germany varies in a range of five to a few hundred. In contrast, there are usually several hundred to thousands of objections against the construction and operation of interim storage facilities for high level and medium level waste. The licensing process for the FRM-II research reactor near Munich resulted in approximately 80 000 objections in 1995 during the environmental impact assessment.

Stakeholder involvement which is not incorporated in the relevant legal process (Atomrechtliche Verfahrensverordnung, Nuclear Licensing Procedure Ordinance) typically manifests itself in the form of public protest. The number of participants in such protests generally varies between dozens and tens of thousands. The majority of protests are against or motivated by transport of used or spent nuclear fuel. More recently, there have also been protests against the transport of decommissioning waste. In light of these tendencies, voluntary arrangements for taking account of public opinion have been established, although these are not required by law. This additional participation partly takes place for licensing second and subsequent phases of the decommissioning process.

While stakeholder involvement took place during the licensing process for the first decommissioning licence, from a legal basis there was no obligation to involve the public during the further steps. In the case of decommissioning of the Obrigheim nuclear power plant, public groups felt their opinion was ignored, with important information not being shared by the relevant authorities. Although not legally required, an information meeting was organized by the authorities in 2012 to discuss the third dismantling phase of the nuclear power plant. In advance of the meeting, opportunities were provided for submission of objections against the intended measures. The organizers of the meeting were both the Ministry for Environmental Protection and the operator of Obrigheim nuclear power plant. The opportunity to be involved was well accepted by the public and the barrier of limited understanding was partly overcome during the discussions. The public involvement approach followed was aligned to the legal requirements applying during an environmental impact assessment. In contrast to this official approach, results and contents of the discussion were put on the Internet and are in the public domain. This leads to an improvement of transparency during the further steps in the process of decommissioning.[17]

[17] See http://www.um.baden-wuerttemberg.de/servlet/is/95181/

IX.2. STAKEHOLDER INVOLVEMENT IN UKRAINE

IX.2.1. Overview of stakeholder involvement and constraints

Owing to historical circumstances, Ukraine has two problematic sites which require significant D&ER, being the Chernobyl nuclear power plant accident site and the Pridniprovskiy uranium legacy site, both of which are operated by the Chernobyl Exclusion Zone Administration and State Enterprise ‘Barrier’, respectively. Since November 2013, the media in Ukraine have published a growing number of news items negatively describing the work of the Exclusion Zone administration and the ongoing implementation of the decommissioning activities. There are various reasons, including: a national political crisis; and frequent management changes in the operating organizations, ministries and institutions concerned with environmental protection and radioactive safety. This criticism has impacted negatively the social and psychological climate among the management and staff on the site.

Despite the negative experience, the emerging role of information resources and increasing importance of journalists’ work has prompted the Ukrainian authorities to develop more effective engagement processes with stakeholders. In line with this, various press tours for Ukrainian and European media have been organized, involving meetings with the Exclusion Zone administration and Chernobyl nuclear power plant management at which the positive aspects of the projects were presented. These activities were organized to facilitate full media coverage of Chernobyl nuclear power plant project, including Chernobyl nuclear power plant decommissioning activities, construction of the New Safe Confinement and international projects within the Exclusion Zone.

In the case of the Pridniprovskiy Uranium legacy site issues, the local population is very sensitive to ensuring radiation safety and environmental situation in the nearby city Dneprodzerzhinsk. There are many industrial enterprises located in the town, predominantly connected to the mining, metallurgical and chemical industry, which still use old technologies and cause a substantial radiological negative impact on the town. There is a general lack of credible information on the environmental effects of uranium legacy facilities based on radiation, ecological and toxicological risks. Public organizations are generally not involved in the discussion of: the results of hazard assessments, long term remediation planning and strategies, and discussions during the preparation of managerial decisions. This situation has led to a lack of confidence in the assessments of the end state of industrial and adjacent areas after completion of their remediation.

IX.2.1.1. A lack of motivation to participate in the process

The selection of the optimal approach to the rehabilitation of the former industrial area of Pridniprovskiy Chemical Plant, the surrounding areas and their subsequent use by Dneprodzerzhinsk was carried out by the operator of the affected site. The following objectives were identified in the request for proposal that will facilitate improved stakeholder involvement:

- Public opinion on the usefulness of the implementation of the programme of rehabilitation of the former Pridniprovskiy Chemical Plant;
- Public involvement in shaping the future image of the city in relation to ideas about the former Pridniprovskiy Chemical Plant industrial zone into an ecologically safe condition;
- Involving the public and professionals in the area of ecology in the process of decision making and in the designing of the final status of the building site, which is aimed at solving social problems;
- Selection of the most promising and productive projects;
- Presenting the selected projects at the municipal level in the media.

IX.2.1.2. Limited access to information and communication

Ukraine’s State Agency for the Chernobyl Exclusion Zone provides information on its web site[18] on public consultations — which have taken place in the past or are planned in the future — concerning documents relating to the environmental remediation and decommissioning activities of the Agency and Chernobyl nuclear power plant.

[18] See http://dazv.gov.ua/

Information concerning the spent fuel management policy of State Enterprise Energoatom (the utility which operates Ukraine's nuclear power plants) is given on its web site[19] and relates to:

— Public notice requirements;
— Provisions for public consultation;
— Establishment of an information repository;
— Availability of technical assistance;
— Development of a community relations plan.

IX.3. STAKEHOLDER INVOLVEMENT IN JAPAN

The Government of Japan, especially the Ministry of the Environment, is responsible for implementing the decontamination activities in the areas contaminated by radioactive materials discharged by the accident at Fukushima Daiichi nuclear power plant operated by the Tokyo Electric Power Company (TEPCO). To promptly reduce the impacts of the contamination on human health and the living environment, the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011 (the Act) came into force on 1 January 2012[20].

The Act clarifies the roles and responsibility of the national and local governments, TEPCO, relevant stakeholders (e.g. landowners) and the public as follows:

(a) National government: Implement any necessary measures in considering its social responsibility associated with the promotion of nuclear energy;
(b) Local governments: Carry out their roles depending on their natural and social conditions, in cooperation with the national government;
(c) TEPCO: Implement any necessary measures in good faith, while assisting the national and local governments;
(d) Relevant stakeholders (e.g. landowners) and the public: Cooperate with the national and local governments.

The Act requires the communication and involvement of the relevant actors (i.e. national and local governments, stakeholders and the public) in the preparation and implementation of the decontamination measures as follows:

— Dissemination of information: To obtain popular understanding and cooperation on decontamination measures, the national and local governments disseminate information about the radiological impacts on human health and environment, and the measures to reduce such impacts.
— Consultations and consensus: Before monitoring the radiation levels of the lands and buildings, the government gives prior notice to the landowners and other relevant stakeholders, and provide the opportunity to express an opinion. Before conducting the decontamination work, the governments obtain written consents from the landowners and other relevant stakeholders.
— Cooperation: The landowners and other relevant stakeholders cooperate with the government for smooth implementation of the decontamination work.

IX.3.1.1. Overview of stakeholder involvement and constraints

From the viewpoint of the stakeholders, the decontamination work is viewed and expected as an action to recover their properties that have been contaminated by the accident to the original status. However, due to the

[19] See http://www.energoatom.kiev.ua/

[20] Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011, Act No. 110, 2011.

limitation of the adopted decontamination measures, radioactive dose may not be lowered to the level as expected by the stakeholders. Such a guarantee is not provided in such activities as removing of topsoil from farmland, cutting trees and plants in the garden. The gaps of understanding between the implementers and receivers of the decontamination activities need to be resolved during explanatory meetings or through the process to obtain the consents for the decontamination activities. This gap still remains and may cause trouble in the future.

IX.3.1.2. Necessity of the stakeholders' trust in the decontamination implementers and workers

After the decontamination activities began, many decontamination workers come to the community from outside the immediate region. In some areas, the number of the decontamination workers exceeds the local population and eventually the ratio of non-locals to the original residents in the community increases. The local residents are likely to be concerned about the change of the community's atmosphere, deterioration of public security and generation of traffic jams. In the evacuation area where the decontamination is being performed, local residents are reluctant to attend the work sites, owing to the reliance on outside workers. Unless the trust of the stakeholders is built, it may become challenging for the implementers and workers to explain their plans and results of the decontamination activities to the stakeholders. To address such concerns, various efforts to build a relationship of trust between the local residents and the decontamination workers have been made, such as:

— Helping residents to understand the decontamination process through visits in advance of decontamination work;
— Installing signage along the roads in the work areas to explain that decontamination work is being carried out;
— Providing means to enable local residents to check residual contamination levels;
— Establishing a resident consultation contact and call centre for decontamination work issues, and carefully responding to requests and questions from the residents;
— Participating in, supporting and sponsoring local events in the work areas;
— Conducting patrols to check the safety in the areas of the residents.

In addition, a contact office has been established by the Ministry of the Environment to receive information from local residents about inappropriate implementation of decontamination work through telephone or email. The information and instruction, if necessary, are given to the decontamination implementers to address the matters and the progresses and results are provided on a web site.

IX.3.1.3. Competing expectations and demands of the stakeholders

The basic objective of the decontamination work is to reduce external exposure dose and to facilitate residents' returning to their previous lives as early as possible, while trying to avoid damages caused by the decontamination work to residents' properties as much as possible. In reality, however, there are different expectations, demands and life styles among the residents. When the decontamination work is conducted (e.g. in farmland or gardens) some people may ask to have the soil, trees and grass completely removed, but others may request to keep them as much as possible as not to destroy their properties. If such different expectations and demands are given on a larger scale, it becomes very difficult for the governments to prepare appropriate plans and to effectively perform the decontamination activities. Therefore, close communication with the residents is required to assess whether and how decontamination is conducted on each item, based on the comprehensive judgement on the degree of decontamination and the importance for the residents.

IX.3.1.4. Escalating expectations and demands of the stakeholders

If the decontamination work is implemented by simply following the expectations and demands of the stakeholders, it may go beyond the work scope which is determined as a standard or regarded necessary and optimal. When other stakeholders request a similar level of treatment, the implementer and workers may need to explain that it is impossible to meet their requests because such work was not originally required. In such cases, the stakeholders feel that they are not being treated fairly or equally. If they fail to explain properly, they will lose the trust. Furthermore, the work beyond the standard results in not only the increase of working time and labour, but also the increase of removed soil and decontamination waste, and in the end, may lead to serious situations including delay of the scheduled work, increased costs and shortage of temporary storage sites. Therefore, to maintain consistency and make uniform and rational decisions concerning the decontamination work, necessary steps are being taken by decontamination work supervisors, rather than by the decontamination workers, to listen to the expectations and demands of the stakeholders, and to make and leave a record of decisions under the supervision of the national government officials responsible for decontamination. Standardized techniques and methodologies of decontamination as well as frequent questions and answers are compiled in guideline documents and disseminated through pamphlets and web sites.

IX.3.1.5. Unclear perspectives of the stakeholders concerning the end point of the waste

Waste is generated in a large quantity through the decontamination work. As the radiological concentration of the waste is very low, it is considered that technologies to safely store and dispose of such waste are available. It is planned that such waste is stored in temporary storage sites and will be transferred and stored in the Interim Storage Facility in Fukushima Prefecture. It has been decided that the final disposal will be done outside Fukushima Prefecture. Temporary storage sites are places where the waste is stored temporarily until the next and final disposal places are found. Structure of temporary storage sites and measures to maintain the safety of the sites are explained through various channels, such as TV programmes, pamphlets and web sites. However, the stakeholder of the lands and neighbouring residents are concerned when the waste stored in the temporary storage sites will be removed if construction of Interim Storage Facility takes a long time. Local people object to the establishment of temporary storage sites, which inevitably cause the delay of the planning and implementation of the decontamination work. To address and reduce such concerns of the local people in Fukushima Prefecture, the Minister of the Environment has taken a lead to demonstrate the efforts of the national government in developing the Interim Storage Facility.

IX.4. STAKEHOLDER INVOLVEMENT IN BRAZIL

IX.4.1. Overview of stakeholder involvement and constraints

IX.4.1.1. Brief description of the Poços de Caldas Site

The uranium mine and milling facility located at Poços de Caldas (State of Minas Gerais), CIPC, was operated from 1982 to 1991. All the economically recoverable uranium has been extracted and currently no mining activity is under way. The main facilities of concern that will require proper attention regarding the remediation of the site include the open pit, the waste rock piles (that are acid-drainage generators) and the tailings dam. This entire area is still under control by the operator and effluents that are discharged into the environment are controlled by means of environmental monitoring programmes. From 1982 to 1991, 1170 tonnes of ammonium diuranate were produced at the site. The tailings generated during this time are deposited in a 29.2 ha dam system, with an actual volume capacity of 1 million m^3. In addition to the tailings and waste rock, other radioactive material/waste is stored at the site:

- — 13 000 metal drums of 50 L each containing in total 1300 tonnes of mesothorium.
- — 2 700 metal drums of 50 L each, stored in 5 silos excavated on a clay bank on the slope of the CIPC waste dam, corresponding to 270 tonnes of mesothorium. The silo is lined and covered with a layer of clay and soil, 3 m thick.
- — 5 800 metal drums of 50 L each, placed in trenches, in 1984, corresponding to 610 tonnes of mesothorium. These trenches are covered with a layer of clay and soil 2 m thick.
- — Approximately 13 200 tonnes of uranium and thorium concentrate are stored in 200 L metal drums and 100 L plastic containers inside sheds and in bulk, inside concrete silos.

The remediation of the site will need to deal with these materials and solutions towards their final disposal will need to be provided.

IX.4.1.2. Licensing process and stakeholder issues

When the licensing process took place in the late 1970s to the early 1980s, no plans were made to address this stage of operations (closure and remediation). In addition to this, mechanisms for public consultation in Poços de Caldas did not exist. The lack of a clear process for stakeholder involvement since the very beginning of mining operations has generated distrust of the local community, not only on the conduct of the mine operator, but also on the regulators involved in the control of the operation. Nevertheless, in recent years, after the cessation of operations, several public meetings have taken place, mainly motivated by demands of non-governmental organizations and triggered by concerns of the population about the safety aspects of the operations. In general, these meetings have placed the mine operator in a defensive or reactive position, resulting in ineffective and tense dialogue. This situation is not helped if the surrounding communities perceive that decisions about the remediation of the site are being considered without their inputs or participation, particularly decisions concerning the proposed end state for the site. The proposed end state is of particular importance because this will establish the criteria for the target residual levels of contaminants in the environment [38].

In response to public concerns about mining projects, mechanisms for stakeholder involvement in decisions concerning the licensing process of mining operations have been established. The most popular ones are the public hearings. The environmental regulatory body, Brazilian Institute of the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, IBAMA), makes use of these events to inform the local community about impacts on the economic, physical and social issues caused by the operation of a mining project. However, by legislation, a uranium mining and processing plant is not regulated solely by the environmental regulator at the state and federal level. The Brazilian National Nuclear Energy Commission (Comissão Nacional de Energia Nuclear, CNEN) plays the key role as the nuclear regulatory body, and in many situations, it is perceived by local communities, where uranium mining projects are developed, as the main responsible party responding to regulatory issues regarding this type of operation. The situation gets even more complicated when it is seen that uranium mining and processing operations are state owned activities and the independency of the regulatory body (mainly the nuclear regulatory authority) is questioned, or at least put under scrutiny. It is not common for an 'independent' organization to be requested to provide regulatory oversight and this undermines the trust the communities may have on the regulatory process carried on regarding that specific operation.

IX.4.1.3. Approaches to overcome the barriers regarding stakeholder influence in decommissioning and remediation project implementation

The environmental remediation of the Poços de Caldas facilities and site has not yet been implemented. However, in view of the above it may be anticipated that a series of constraints will be faced by the mine operator (D&ER implementer) when these activities are set to be put in place and clashes between community representatives and non-governmental organizations against D&ER implementers and possibly regulatory organizations are anticipated and will add to the situations that have already taken place and have been reported above. The consequence of this potential scenario will be the creation of impediments to the implementation of intended operations, escalation of costs and delay of the D&ER process. In addition to those issues, it has been suggested that the lack of communication or failure in the communication process with the neighbouring population and with other regulatory bodies may lead to judicial orders that will cause the interruption of remediation and in a more radical scenario even delay or prevent the remediation activities of the site. It has been pointed out that the lack of a well structured communication programme with politicians and the general public may turn into a very difficult enterprise for the selection of a site for the construction of a facility for the disposal of the radioactive waste generated with remediation operations.

Avoiding this situation and overcoming eventual constraints related to D&ER is still possible and will depend on a strong commitment of the owner or implementer and regulators (independently from each other but still in coordination) in implementing programmes with public involvement, consultation and engagement in the decision making process. Both operator and regulators should be open and honest with the prospective participants about the reasons for being involved, providing all the information and means to ensure active and representative participation of stakeholders at key points of the remediation programme. It is crucial the whole life cycle of the process is clearly described with the associated time line for activities implementation. A starting point is an agreement on the intended end state of the site.

A description of the rehabilitation and closure plan has been developed for the site[21] and there is general recognition of the importance of undertaking dialogue with local stakeholders before the detailing and implementation phases take place. In light of this, the project has been presented to the Brazilian environmental and nuclear agencies, as well as to the local communities, although currently without a well established strategy for stakeholder involvement. Nonetheless, this represents important progress in comparison with approaches adopted in the past.

IX.5. STAKEHOLDER INVOLVEMENT IN THE UNITED STATES OF AMERICA

The Fernald Environmental Management Project site is a remediation site near Cincinnati, Ohio. At this site, a facility for uranium purification was operated that produced over 250 million tonnes of high purity uranium. During operations, about 500 000 tonnes of contaminated material was released to the surrounding environment and through the groundwater to a nearby aquifer.

For this remediation programme the United States Department of Energy (DOE), the United States Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (OEPA) established the Fernald Citizens Task Force. It was composed of 14 members from the local community, experts and non-voting members from the DOE, EPA and OEPA.

The goals of this Task Force were:

(1) What should be the future use of the Fernald site?
(2) What residual risk and remediation levels should remain following remediation?
(3) Where should the waste be disposed?
(4) What should be the priorities among remedial actions?

Within seven months the task force released recommendations for these questions. They were answered by conducting monthly public Task Force meetings, two workshops to enhance public understanding and involvement in the remediation levels, future use and waste disposition issues. To be sure all sides were heard, personal invitations to stakeholders were made to identify the issues and decisions to be addressed in upcoming meetings.

The following proposals to the regulators were given by the Task Force:

(a) For goal 1:
- — For the land to be used productively, the remediation levels recommended for the site should provide for all uses other than residential or agricultural;
- — A sufficient buffer should be provided between the on-site disposal cell and any other uses of the property;
- — Specific uses of the property would be best determined closer to the time of reuse by the people most impacted by that use.

(b) For goal 2:
- — The aquifer should be restored and protected to conform with maximum contaminant levels for all contaminants under the Safe Drinking Water Act;
- — The excess risk of cancer during an individual’s lifetime should be reduced to one in 10 000;
- — The non-cancer risks should be reduced to a level at or below the EPA target for hazard index of one.

(c) For goal 3:
- — The most highly contaminated materials should be disposed off-site;
- — The on-site disposal facility should be constructed to store materials with low levels of contamination from only the Fernald site.

[21] See http://www.mineclosuresolutions.com/wp-content/uploads/2014/05/Session-5-Freitas-Antônio-H.-A.-Rehabilitation-and-closure-plan-for-a-uranium-mining-complex-in-Brazil.pdf

(d) For goal 4:
- — An accelerated remediation schedule should be adopted to provide rapid protection of human health and the environment, and to control overall costs;
- — Non-remediation costs should be reduced as quickly as possible and redundant requirements eliminated;
- — Higher risk waste awaiting shipment from the site should be removed immediately.

After close interaction between all involved parties (Task Force, DOE, EPA and OEPA) the programme was finished with closure of the site in 2006.

Most of the site is restored to native wetlands, prairie and woodlands. A centre was built on-site to show photographs and videos of Cold War history and the remediation at Fernald, to display Native American artefacts found on-site and to educate the local public on the history of the site.

IX.6. IAEA, OECD NUCLEAR ENERGY AGENCY PUBLICATIONS REFERENCES AVAILABLE

The IAEA and the OECD Nuclear Energy Agency have each published several reports on stakeholder involvement at different stages of the fuel cycle (see Table 9).

TABLE 9. REFERENCES WITH DESCRIPTIONS

Publication	Description
Nuclear Communications: A Handbook for Guiding Good Communications Practices at Nuclear Fuel Cycle Facilities [39]	The purpose of this handbook is to provide information on applying good communication practices concerning nuclear fuel cycle facilities. It is a compact source of information for people involved in plant operation and management and identifies and addresses questions that members of the public may have about different aspects of the nuclear fuel cycle.
IAEA-TECDOC-1076, Communications on Nuclear, Radiation, Transport and Waste Safety: A Practical Handbook [40]	This publication is intended for national regulatory authorities to provide them with information on the principles and methods that can be applied in communicating nuclear safety to different audiences under different circumstances. This publication presupposes the existence of an adequate national infrastructure, including an independent regulatory authority with sufficient powers and resources to meet its responsibilities.
IAEA-TECDOC-1553, Low and Intermediate Level Waste Repositories: Socioeconomic Aspects and Public Involvement (Proc. Workshop, Vienna, 2005) [41]	This publication summarizes discussions of a three day workshop on socioeconomic issues and public involvement practices and approaches for developing and operating repositories for low and intermediate level waste which took place in the IAEA headquarters on 9–11 November 2005. Particular States described both principles and practices applied, providing a useful overview of potential approaches for dealing with non-technical issues during a repository life cycle. The final discussion concentrates on the application of incentives to local communities and on ways to attract general public when developing or operating a waste disposal facility.
INSAG-20, Stakeholder Involvement in Nuclear Issues [42]	This is a publication by the International Nuclear Safety Group (INSAG) which establishes that substantive stakeholder communication and involvement contributes to the safe operation of nuclear facilities and discusses ways and means for the efficient and rational involvement of stakeholders in the consideration of nuclear issues. INSAG concludes that decisions concerning matters such as the siting and construction of a nuclear power plant are no longer only the domain of a closed community of technical experts and utility executives. The concerns and expectations from a wide field of individuals and organizations also need to be considered. The publication is intended for use by all stakeholders in the nuclear community, including national regulatory authorities, nuclear power plant designers and operators, public interest organizations, the media, and local and national populations.

TABLE 9. REFERENCES WITH DESCRIPTIONS (cont.)

Publication	Description
NEA/RWM/WPDD(2006)6, What We Heard within WPDD on Stakeholder Involvement in Decommissioning, 2001–2004 [43]	This document contains a compilation of papers regarding stakeholder involvement in decommissioning given at WPDD meetings and workshops between 2001 and the end of 2004. The compilation is focused on lessons to be learnt and includes examples of key statements by representatives from different OECD Nuclear Energy Agency Member States involved in, or affected by, decommissioning projects.
Stakeholder Involvement in Decommissioning Nuclear Facilities: International Lessons Learnt [44]	This publication considers each decommissioning situation as a product of its specific context. There is no ‘one size fits all’ solution, and in each context, stakeholders will have to work out views and agreements in a way consistent with both their legal system and national culture. The findings in this publication about national practice and experience are offered to stimulate reflection and discussion.
NEA/RWM/WPDD(2008)8, Proceedings of the Topical Session of the 9th Meeting of the WPDD on “Human and Organisational Factors in Decommissioning” [45]	This publication provides the broad overview of decommissioning and dismantling issues by representatives from different OECD Nuclear Energy Agency Member States through their work as regulators, implementers, R&D experts or policy makers, in particular: — Project management and contracting schemes being used for decommissioning projects and the benefits which may be gained from including former operational staff in decommissioning teams; — Planning and record keeping, including the extent to which inadequate historical records need be reconstructed; — Approaches to workforce management, particularly in regard to safety.
IAEA Nuclear Energy Series No. NW-T-2.5, An Overview of Stakeholder Involvement in Decommissioning [46]	This publication identifies the broad range of stakeholders, their interests and interactions, and how these have affected actual decommissioning projects. The publication takes due account of the environmental, sociopolitical, economic and cultural diversity among IAEA Member States, as well as the work of other organizations, in particular the OECD Nuclear Energy Agency. As a result, this publication presents a thorough analysis of concerns typical for stakeholders and the approaches that have been adopted to reconcile them.
IAEA Nuclear Energy Series No. NG-T-1.4, Stakeholder Involvement Throughout the Life Cycle of Nuclear Facilities [47]	While acknowledging the existence of different national approaches, this publication proposes a route to effective stakeholder involvement throughout the main phases of the life cycle of nuclear facilities (i.e. construction, operation, radioactive waste management, decommissioning) and the use of up to date methods to implement stakeholder involvement programmes.
IAEA Nuclear Energy Series No. NW-T-3.4, Overcoming Barriers in the Implementation of Environmental Remediation Projects [48]	The IAEA acknowledges that public concerns may be a driver but also a constraint in remediation programmes due to public demands for revised end point or potential legal actions against the project. These societal constraints can result in significant impacts in the cost and schedule of the project. These constraints are discussed in this publication.
IAEA Nuclear Energy Series No. NW-T-3.5, Communication and Stakeholder Involvement in Environmental Remediation Projects [49]	This publication provides an integrated overview of the challenges and possible approaches in making stakeholder involvement and communication more effective in the design and implementation of remediation processes. It offers regulators and operators strategies to involve stakeholders in the communication process and approaches for effective communication with all relevant interested parties in environmental remediation projects.

ABBREVIATIONS

ALARA	as low as reasonably achievable
APS	alternative energy source
CEG	IAEA Contact Expert Group
CIDER	Constraints to Implementing Decommissioning and Environmental Remediation
D&ER	decommissioning and environmental remediation
DOE	United States Department of Energy
EBRD	European Bank for Reconstruction and Development
EPA	United States Environmental Protection Agency
IDSF	International Decommissioning Support Fund
IRRS	International Regulatory Review Service
NIMBY	not in my back yard
NORM	naturally occurring radioactive material
OEPA	Ohio Environmental Protection Agency
OSH	occupational safety and health
RHS	radioactive heat source
RPV	reactor pressure vessel
RTG	radioisotope thermoelectric generator
TEPCO	Tokyo Electric Power Company
UNDP	United Nations Development Programme
Wismut ERP	Wismut Environmental Remediation Project

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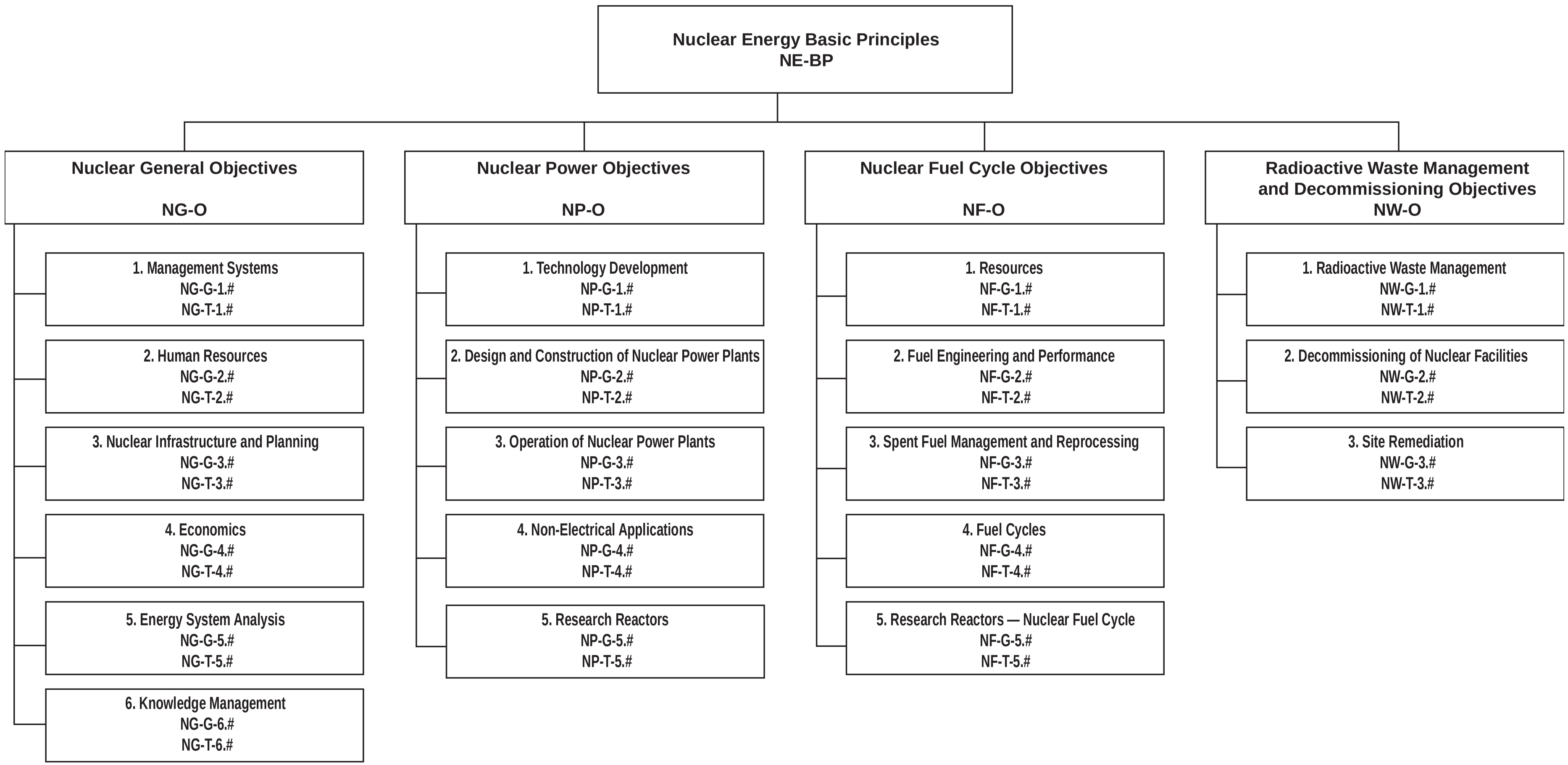

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