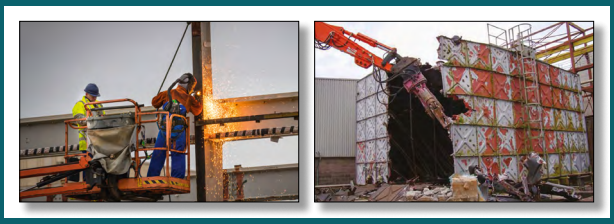
Human Aspects of Nuclear Safety
2022

Organisational Capabilities for Decommissioning Nuclear Installations



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Human Aspects of Nuclear Safety

Organisational Capabilities for Decommissioning Nuclear Installations

NEA No. 7580

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The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Cover photos: Dismantling of the Dounreay fast reactor research and development centre, United Kingdom (Dounreay Site Restoration Limited [DSRL] and Nuclear Decommissioning Authority [NDA]); decommissioning redundant buildings at Hinkley Point A, United Kingdom (NDA).

Foreword

This report brings together the guidance and experience of nuclear decommissioning from members of the Nuclear Energy Agency (NEA) Working Group on Human and Organisational Factors (WGHOF). WGHOF members reached out to other individuals and organisations who shared their experience of delivering decommissioning programmes and activities, as well as to those responsible for regulatory oversight.

There is the potential to gather much more operating experience in this area as more countries embark upon and expand decommissioning activities. At the same time, this report provides a succinct overview as a starting point.

This guide can be used as a resource for self-assessment for any organisation involved in decommissioning. It provides a topic-by-topic overview, case studies and other lessons learnt and summaries of good practices to help support both licensee organisations and regulatory bodies.

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List of abbreviations and acronyms

D&D	Decommissioning and dismantling
HOF	Human and organisational factors
HTO	Human, technology and organisations
IAEA	International Atomic Energy Agency
MODP	Magnox Optimised Decommissioning Programme (United Kingdom)
NDA	Nuclear Decommissioning Authority (United Kingdom)
NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
OPEX	Operating experience
SLC	Site licence company
SSC	Systems, structures and components
WGHOF	Working Group on Human and Organisational Factors (NEA)
WPDD	Working Party on Decommissioning and Dismantling (NEA)

Executive summary

Background

The number of nuclear reactors approaching decommissioning, or already in the process of decommissioning, is increasing globally. Planning and performing decommissioning and dismantling activities raises different safety challenges compared to steady state electricity generation. As a result, decommissioning experience is growing worldwide, but there can be a tendency to focus primarily on the technical aspects of the work, and less on the human aspects.

With regard to human and organisational factors (HOF), the principal challenges and solutions will depend on the decommissioning strategy. Nuclear organisations approaching decommissioning will need to adapt in accordance with the chosen strategy, and will need to address the issue of organisational change.

Since there are many common challenges related to HOF and safety, it is worth discussing and sharing experience on how to deal with these challenges.

The strategy for the NEA Working Group on Human and Organisational Factors (WGHOF) was to build on existing knowledge in this area in order to identify important challenges, and to provide a WGHOF view on ways to meet those challenges.

Objectives and scope

The primary objective of this report is to address HOF for all phases, including the transition from generation operations to end of generation, defueling, decommissioning, and dismantling of nuclear facilities.

The report also provides an assessment of HOF during the different decommissioning phases, within a systemic approach to safety.

It provides practical guidance on integrating the identified key organisational capabilities within new or existing organisations required for effective and safe nuclear decommissioning.

Its purpose is to also collate learning in this area and to share it as a practical aid for licensees and regulators.

This report discusses the safety challenges in decommissioning, the phases of decommissioning, and the human and organisational challenges associated with the transition from generation operations to decommissioning.

While the report focuses primarily on nuclear, radiological, and conventional safety, it is important to note that similar considerations also apply to environmental safety.

Relevant learning and topical case studies from global decommissioning activities are included where available to help inform organisations in their endeavours in this area by sharing good practice and experience.

Conclusions and findings

To ensure plant and personnel safety, human and organisational factors should not be treated as a side task during decommissioning. Instead, human and organisational factors need to be integrated into the broader management system throughout the phases of decommissioning.

It is especially important to include HOF in the hazard and risk assessment and safety cases in order to be able to make risk-informed decisions and thus establish a good prioritisation of where and when human and organisational factors need to be addressed and to what extent.

The following prioritised areas describe the key organisational capabilities identified for decommissioning and are presented in detail as a coherent framework in Chapter 4. In Chapters 5 and 6, this report summarises good practices (for each of these four prioritised areas) for licensees and regulators, respectively.

Capable and competent workforce

This element of the framework focuses on the need to plan for and retain sufficient capabilities throughout all phases of decommissioning. There should be an overarching strategy for the management of capabilities on site including role profiles, training, change management, intelligent customer functions and supply chains.

Effective leadership and governance

This element focuses on the pivotal role that leaders play in guiding the organisation through the significant changes associated with moving from operation to decommissioning. Leaders set the tone, standards and expectations that are key to diligent and safe decommissioning. In addition to being technically competent, leaders need to engage staff, be role models, communicate clearly and honestly, and be available and visible to the workforce.

Managing culture and motivation

This element highlights the need to ensure that the culture that was present during electricity generation operations is not degraded once generation stops and decommissioning activities commence. As the nuclear hazard decreases, conventional and radiological hazards increase and diligence is required to ensure that safety standards are maintained, especially with a dynamic workforce.

Effective programme and project management

Finally, this element covers the need for an effective decommissioning strategy and plan as the site's focus changes from supporting generation to supporting a dynamic project environment. Intelligent customer competence and effective management of a growing contractor workforce in the supply chain are also key to cost-effective and safe decommissioning.

As nuclear decommissioning activities expand globally, the potential to gather and make effective use of operating experience also grows. This report is a contribution to that effort, and it can be used in self-assessments for operators and regulators to help ensure effective, efficient and safe decommissioning.

Chapter 1. Introduction

While experience in decommissioning and dismantling (D&D) nuclear reactors is growing worldwide, the technical aspects tend to be the main point of focus. Yet the human aspects of planning and carrying out D&D are also key to the projects' long-term success.

Approaches to decommissioning are highly dependent on different factors such as the regulatory framework; the decommissioning strategy (including identified end states and interim states); funding and its delivery model; facility design and status; availability of relevant operating experience; and stakeholder perceptions. All of these factors will influence activities and behaviours and the approaches will differ between countries and organisations. However, with regard to human and organisational factors (HOF), the principal challenges and solutions will depend on the D&D strategy. Nuclear organisations approaching decommissioning will need to adapt in accordance with the chosen strategy, and they will all need to address the issue of organisational change. Since there are many common challenges related to HOF and safety, it is worth discussing and sharing experiences regarding how to deal with these challenges.

This report addresses HOF for all phases, including the transition from electricity generation to end-of-generation and the D&D of nuclear facilities, and provides practical guidance on integrating within new or existing organisations the organisational capabilities required for nuclear decommissioning. It also includes guidance on how these capabilities should be developed and integrated within decommissioning organisations. The document focuses in particular on a review of HOF during the different decommissioning phases, within a "systemic approach to safety". It builds on operating experience already gained and explores the challenges in order to provide guidance for both operators and regulators.

For the purpose of this report, organisational capability is defined as:

- the organisation's ability to manage its activities efficiently to achieve and maintain the highest standards of safety; it requires deployment of an effective management system, sufficient capable human resources, effective leadership, and appropriate governance.

HOF is defined in IAEA, 2018 as:

- the factors that influence, in a positive or adverse manner, human performance in a given situation, keeping in mind that safety is the result of the interaction of human, technological and organisational factors.

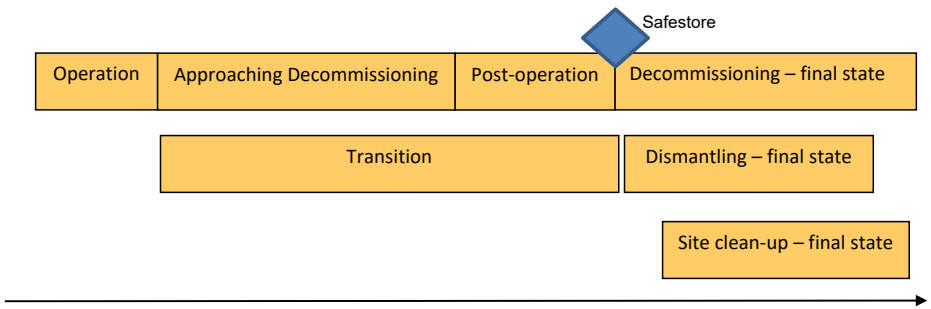
Chapter 2. Decommissioning phases and safety considerations

2.1. Decommissioning phases

A decommissioning strategy should take an integrated approach that includes phasing, waste management, safety cases, organisational capability, etc. It will identify a number of phases. Decisions will be needed on, for example, defining the interim and final end states and the applicable phases of decommissioning, including immediate or deferred dismantling. These decisions will be influenced by defueling timescales and the overall strategy for waste management, including options for spent fuel storage or off-site removal. Timescales are key in developing the strategy to ensure that adequate capability is retained in line with the phasing. The definition and timing of interim and end states needs to be accurate and realistic and avoid an optimism bias. The risk of this can be mitigated by detailed planning, taking into account relevant operating experience, and by building independent challenge and oversight into the production of the decommissioning strategy and its implementation.

The detailed structuring of the different phases depends on the specific national legal frameworks for decommissioning. It will be important to define what the interim and final end states are for the various facilities on site as this will affect what decommissioning phases become applicable. A general overview of the different stages is proposed in Figure 1. The decommissioning strategy will mainly affect the timing of each stage, and in most cases the stages overlap.

Figure 1: **Transition from operations into decommissioning phases**



The activities provided below are indicative only to demonstrate the principle of phasing:

- Operational phase – steady state of electricity generation/outage cycles.
- Operations and defueling preparations – the decision to shut down has been made and preparations for decommissioning have started.
- Post-operation (from the final shutdown) – the fuel is removed from the reactor vessel to spent fuel pools, dry storage and/or to back-end storage facilities. At the start of this phase the fuel is still actively monitored, and by the end of this phase the fuel is no longer on site or is in safe storage waiting for deferred dismantling.
- Safe storage development for fuel and active waste management as required for the specific site.
- Main decommissioning and dismantling (D&D) phase once defueling is complete.
- Final state may be a transition into care and maintenance (defueled nuclear plant is kept intact and is placed in protective storage for an extended period to allow radiation levels to return to normal) or continuous D&D until site remediation and release.

It is important to define the goals of the phases of decommissioning to inform the overall approach and delivery:

There should be proper consideration of nuclear and non-nuclear safety in this overall goal definition. Development of a comprehensive inventory of structures and wastes will assist in accurate definition of this goal.

The defueling organisation structure and the decommissioning organisation structure should be articulated so that staffing levels, roles, management oversight, and training requirements are planned for well in advance.

The identification and definition of the necessary organisational capabilities should evolve over time but should always be anticipated well in advance so as to properly prepare the licensee organisation for the expected changes.

The decommissioning strategy and associated plans should be live documents and subject to change management over time and as conditions evolve.

2.2. Safety challenges in decommissioning

There are three main types of occupational hazards associated with decommissioning facilities:

- Radiation hazards produced by radioactive materials.
- Chemical hazards produced by radioactive materials.

- Facility conditions that result in occupational hazards (hereafter referred to as industrial safety and health hazards). Industrial safety and health hazards include: employee exposure to toxic nonradioactive materials; electrical hazards; falls from height; confined spaces, etc. These hazards will increase as a result of decommissioning activities (including construction and demolition). Additional hazards may also be discovered as decommissioning progresses, e.g. unexpected materials that were used in construction.

As the nuclear risk on the site reduces, decision making will be increasingly informed by other risks and issues, including conventional health and safety (e.g. asbestos, and the risk of the collapse of degraded structures due to inadequate asset management). Any modifications or engineering change processes will need to be proportionate to the residual risk.

From a regulatory perspective, it is also important to be proportionate to the reduced risk on the site. Following defueling there will be fewer requirements for active systems on site, but until all of the radioactive waste has been processed and consigned to controlled disposal routes, active systems will still be required. Subsequently, the focus will shift towards making the plant passively safe and managing assets to prevent degradation over time. It is also important to note that environmental safety should receive a similar focus. Environmental impacts and their management by the licensee will increase workload, as will associated regulatory scrutiny.

Chapter 3. Methodological approach and outcomes

Considerable experience in decommissioning nuclear facilities has been gained over the years from research reactors, operating reactors and nuclear fuel cycle facilities. However, the extent to which experience is documented, exchanged and used is often variable. Research shows that the effective sharing and use of decommissioning experience can prove more valuable than new technological developments. Thus, the strategy of the NEA Working Group on Human and Organisational Factors (WGHOF) was to build on existing knowledge to identify important challenges and to provide a view on how to meet them.

Many aspects of human and organisational factors (HOF) can be relevant to consider. To help prioritise these aspects for licensees and regulators, the first aim of the working group was to identify the relevant HOF areas to consider when approaching and performing decommissioning.

Work began with a "Decommissioning Capabilities Workshop" involving members of the WGHOF representing operators or regulatory bodies. It was held during the 24th WGHOF meeting in Halden, Norway, in March 2018, where presentations (of previous work related to decommissioning) were held and used as a basis of discussion on:

- IFE/Halden research on decommissioning;
- a research project on the assessment of human and organisational factors during decommissioning;
- competence analysis related to decommissioning; and
- the lessons learnt from the exchange of experience regarding oversight in decommissioning.

In addition, work from the NEA Working Party on Decommissioning and Dismantling (WPDD) also served as relevant and useful input (NEA, 2018).

The workshop aimed to identify the main areas of focus for the work and agreed on the following themes, which describe key organisational capabilities for decommissioning:

- capable and competent workforce;
- effective leadership and governance;
- culture and motivation;
- effective programme and project management.

After deciding on the prioritised areas, the following activities were performed:

- a literature review;
- the collection of contributions from WGHOF members who are working on decommissioning as regulatory authorities, licensees or technical support organisations;
- an analysis of the applicability of lessons learnt from organisational capabilities for decommissioning organisations and new builds; and
- workshops with the WGHOF.

Results were then summarised and analysed to identify good practices. However, as noted previously, decommissioning approaches vary across countries and companies due to many factors. These factors include, for example, the funding model, regulatory framework, facility design and status, the available routes for radioactive waste, good practices and experience, and stakeholder perceptions.

Chapter 4. Prioritised human and organisational capabilities

Organisational capabilities for decommissioning should be identified and defined in a systematic way. The process of ending the electricity generation phase and preparing and performing the decommissioning phase will affect individuals and organisations significantly, in different ways, and with an impact on safety.

For instance, the motivation and engagement of the workers may drop and work priorities, processes and procedures will change. The organisation will transform, requiring changes to management practices and worker competencies. In addition, the incorporation of new employees, contractors and management with new skillsets and backgrounds can further lead to cultural change within the organisation. By addressing these challenges with a systemic human and organisational factors (HOF) approach, organisations can help ensure a safe, effective and efficient approach to decommissioning and dismantling (D&D).

The decisions made by the organisation on a D&D strategy will affect what skills are required of the workers and leaders. The morale and safety culture of the organisation will similarly be affected by the actions of leadership in terms of developing trust through open and honest communication.

The four prioritised organisational capabilities that were identified by the literature review and workshops are presented as an enabling framework in Figure 2 below.

Figure 2: **Organisational capabilities for decommissioning**

Each of the four quadrants will be covered in detail in the separate sections below (4.1 to 4.4). However, it is important to note that the quadrants work together to make an overall effective framework and that a coherent and holistic perspective must therefore be taken.

Note that the identification of these areas does not mean that other aspects are irrelevant. There are many organisational factors that contribute to successful delivery such as effective business planning; management of financial resources; investment delivery; deployment of an effective management system; proactive employee engagement; systematic approaches to training; effective communication strategies and processes, and so on. It is important to carry out further studies and share experiences. The areas identified here are priority organisational capabilities to consider in order to reduce the risk inherent in the transition from generating operations to D&D.

4.1. Capable and competent workforce

Identification of resources – competence management approach

The duration of decommissioning projects is such that it is challenging to maintain and forecast the skills needed in the future. There should be an overarching strategy for the management of capability on the site. The strategy needs to reflect the new aims of the changing organisation, for example "retain, retrain and redeploy". Capability and specialist knowledge on site need to change as the on-site operations and focus change. For example, increased capability in waste management and asset management and maintenance will be required. It is worth noting that while the maintenance burden may reduce as the operations at the plant decrease, the introduction of new plant may require new skills. It is also important to maintain operational skills as this pool of experience can support the development of decommissioning techniques and provide skills to operate new plant and equipment.

It is best practice to establish an organisational capability strategy during the planning phase. This will require regular reviews and should drive resource requirements. Both the timing and nature of the end of generation (or other activities) should be established. It is important to ensure adequate financing (where possible) for decommissioning. Thus, an assessment of the financial situation may be necessary. Note that this is a competence the regulatory bodies generally do not have. However, depending on the regulatory requirements of the country, financial guarantees to cover the costs of decommissioning may already be in place.

Operational structures will need to change to meet the requirements of a decommissioning site. There will be a need to develop defueling and decommissioning structures. Changes to organisational structures and numbers must be managed to minimise risks to nuclear safety. Proposals should be carefully assessed and justified. They should be subject to internal review and challenge (via an internal regulatory assurance function) and should be subject to regulatory review where appropriate and in line with a graded approach. It is likely that the regulator will need to see a detailed justification for organisational structures and resource levels at each phase and in site-specific change proposals.

Case study 1: **Financial resources**

The French Nuclear Safety Authority (ASN) has examined the triennial reports submitted by nuclear operators relating to securing the financing of long-term nuclear charges. This evaluation and provisioning system aims to ensure that the costs of dismantling, spent fuel management and radioactive waste are evaluated in a sufficiently prudent manner, and covered by dedicated assets, making it possible to have, when the time comes, the necessary financial means. The regulator has examined the technical assumptions supporting the assessments of these charges. The regulator's main observations are as follows (ASN, 2020):

- The scope of the assessment of the charges identified by the operators remains incomplete (for example, this scope in fact excludes operations with high financial stakes, such as preparatory operations for dismantling, characterisation of soil and pollution, complete clean-up operations).
- The assumptions used for the evaluation of full costs must be reassessed to be more realistic and prudent with regard to the planning of projects and decommissioning programmes, and the risks associated with the unavailability of warehousing, processing and disposal facilities.
- The cost forecasts at project completion must be more detailed and better justified in relation to the progress of the projects.

From both a utility perspective, as well as a regulatory perspective, it is important to follow staff turnover and evaluate the activities performed to ensure that enough (critical) competence remains within the organisation. To be able to do this evaluation, critical competencies that are needed to safely continue operation until the end should be mapped. Further, it is important to identify competency requirements for decommissioning. There have been examples where the knowledge of the utility personnel has not been adequate in these new competency areas. The operator needs to consider what plant systems will be needed going forward and when plant systems will no longer be needed as this also helps determine the "demand" side for people's skills and knowledge. Every plant system should be reviewed in detail.

As well as understanding the "demand" side for qualified workers, based on an analysis of work activities at a particular phase, licensees also need to understand their "supply" side, based on what skills and knowledge are actually available in the workforce and are likely to be available in future.

The operator will have to decide on the balance of in-house and external (contractor) resources and appreciate that this balance is also likely to change over time. This requirement will change as work demands fluctuate. Sharing plans and building alliances with contractor supply organisations will help mitigate the impact of these changing work demands. This is explored further in Section 4.4.

Case study 2: **End of generation, defueling and decommissioning of the UK's Magnox reactor fleet – workforce planning, managing organisational change and regulation**

In the United Kingdom, 11 Magnox design power stations were built with 26 operating units in total. The last reactor ceased generation in 2015. All of the sites have now defueled and have entered the next phase of decommissioning. One site has entered a quiescent "care and maintenance" state.

Across the nuclear industry, organisational change has been sometimes poorly managed, and the UK regulator had concerns that ultimately resulted in a change to the licence conditions that apply to each nuclear site. A new licence condition was introduced that required the operator to make adequate arrangements for managing change, including classification of changes according to their nuclear safety significance and provision of documentation to the regulator justifying the safety of changes in the higher categories. It also gave the regulator the power to halt organisational changes if safety concerns were not addressed. In 2011, as a result of a European Directive, this licence condition was modified further to include an overarching requirement to maintain adequate human and financial resources to ensure safe operation.

In the early days of decommissioning these sites there was a focus on reducing costs through reducing staff numbers. This highlighted the fact that carefully identifying the "demand" side of the supply/demand model is vital and at first this was not optimised. Key staff were released early under staff reduction schemes and later their skills were needed again and had to be reacquired. This is not a unique scenario and this optimism bias has been seen elsewhere. It should be recognised that the transition from one operational state to another can take longer than originally planned and contingency needs to be in place to cater for this.

It is important to remember that the generation-based skills and knowledge will largely be the same for defueling, which can typically take three to four years, so there is a need to retain these experienced people. For example, skilled maintenance personnel with experience of working on defueling equipment should be retained. HR release schemes took this into account and staged the release of some staff until defueling had been completed.

If one reactor continues to generate while the other shuts down, it will be necessary to maintain these diverse skills and knowledge; this will need to be managed to ensure that the right skills are maintained. The availability of skills and knowledge must always focus on the safe operation of the operating reactor.

More engineering support was needed than originally planned as the sequencing of the removal of systems was not initially correct, preventing the optimisation of the maintenance schedules, which resulted in additional time and effort being expended in maintaining redundant plant and equipment. Equally, the continued need for site infrastructure meant that the amount of maintenance required on the building fabric was underestimated. There was also a recognition that better alignment was needed between fuel route operations and maintenance.

The capability for managing the permit-to-work arrangements was also underestimated whereby this knowledgeable resource was reduced prematurely. This in turn restricted the timely release of plant and equipment for work.

Knowledge management

One of the main challenges that the working group identified was retaining knowledge and competence during the "approaching decommissioning" phase and building knowledge for a potential new licensee responsible for the decommissioning.

Properly managing knowledge and information while experienced staff are still available is essential. This is particularly important in terms of understanding the condition of the plant to inform D&D. For example, how is the existing plant different to the as-built plant? The retirement ages of staff need to be considered when understanding risks to organisational capability – could there be a significant reduction in the most knowledgeable/experienced staff on site in a relatively short time period? Retaining certain operating personnel for dismantling is important because of their good knowledge of the installation. However, D&D techniques differ greatly in a decommissioning environment compared to an operational environment. The handing over of areas of a plant to specialist demolition contractors simplifies this process. What is important is getting the balance right between retaining plant knowledge and engaging demolition contractors. The operator needs to ensure that there are suitably qualified and experienced staff producing and reviewing new safety cases.

Measures to retain and build competence should cover licensee and contractor personnel as well as the regulatory body. Tasks may require expertise to an extent which may only be available in subcontractor organisations or teams of the licensee organisation which are not permanently on site and may therefore be less familiar with site-specific issues. In such cases, a good practice would include identifying the required expertise of qualified contractors as well as identifying the knowledge plant personnel must have to co-operate effectively with contractors' (or off-site licensee) personnel during the planning, preparation and performance of tasks. In these circumstances, the role of plant personnel is to ensure that nuclear safety, radiological protection, and site-specific aspects are given proper consideration by means of information, supervision and quality assurance. This is commonly known as having "intelligent customer" capability. Training plant personnel for effective co-operation with contractors might include soft skills such as communication and leadership.

With regard to retaining knowledge, experience shows that licensees need to work with different incentives, address motivational aspects and encourage leaders to actively engage personnel. Economic incentives, both bonuses and employment guarantees, are common and useful, though incentives could also be of a non-pecuniary nature. They need to be considered carefully so as to ensure that they do not drive the wrong behaviour and that a focus on safety is maintained. The prospect of a new professional qualification or the possibility of retraining can be a motivating incentive. With respect to reactors, managing the removal of fuel, programme and project management, and radiological protection are examples of where further resources will be needed. Ideally, new opportunities should form part of the announcement of the decision to shut down. Otherwise, many people might start to worry and look for other positions, and it can be more difficult to keep them after they have started to look for a new job.

The operator should be aware that where there is uncertainty about redundancies on site or the security of work, the most capable, employable, and mobile individuals may leave first to seek other work. Risks to capability should be considered when setting notice periods for staff leaving and in assessing how soon that resource could be replaced. Individuals with unique, specialised knowledge who are vital to managing specific risks should be identified and, where possible,

resilience (i.e. resource defence in depth achieved for example through job shadowing) should be increased.

Where there is a fleet approach, it may be possible to introduce a resource protocol that seeks to match potential vacancies at other stations with the career aspirations of staff at the affected station. This may enable a managed and phased approach to staff release. It is also important to conduct activities to understand why people leave to be able to take corrective actions, if needed. Exit interviews may be a helpful tool in this regard.

From a regulatory perspective, it is important to ask the licensees early how they have mapped the critical competencies to gauge their risk assessment and to evaluate whether the actions taken are relevant and in accordance with the risk level. Monitoring the operators' arrangements for managing organisational change is crucial at this time.

Utilities are advised to develop (and regulators to oversee) future job profiles and to show what challenges need to be addressed and what types of tasks will exist in the decommissioning stages.

Change of operating organisation

The operating licensee may not be the operator responsible for the decommissioning phases. Knowledge management is a key activity as different areas of the plant may change ownership during this transition from generation to decommissioning.

There is therefore a need to build competence to appreciate the scale of the task as well as to understand the factors that are unique for nuclear sites. In this, there are many similarities with new build organisations. Commendable practices from new builds show that early engagement (prior to formally submitting an application) is vital. The regulator can also encourage new licensees to interact with existing licensees, with a priority on other licensees performing decommissioning.

As the regulatory framework for decommissioning can vary between different countries, it is also important to understand the regulations and processes for nuclear waste disposal. A challenge is that decommissioning is performed within a strict economical envelope as it does not generate revenue. Thus, a new licensee is not likely to have an organisation up and running before it is really needed, which in turn will make it difficult to perform this early engagement. Regulators need to be aware of this and require certain information (e.g. a plan for organisational staffing for the decommissioning organisation) to start the discussions and to assess if the new licensee appreciates the scale of the task. It is also possible that existing staff will transfer to the new organisation so it will be crucial for the existing and new licensees to work closely together on all aspects, including identifying which skills and competencies will be needed and therefore which staff to retain. If there is a significant delay between the end of generation and the start of defueling, there may be difficulty in retaining operational staff and their skills.

Contractor-managed areas also pose a challenge to maintaining competence. Regulatory processes need to be developed for the oversight of contractor islands. The customer (licensee) needs to be an intelligent customer, but they also need to monitor

and perform oversight of the contractors to ensure smooth progress. Regulators need to oversee the licensee to ensure that they are providing appropriate oversight for the contractors working in their facilities.

Retraining staff to build capability

Decommissioning programme management skills are different from those required for operations and will not be mature in an operations-focused workforce. There will be a need to develop the skills of programme managers early in order to meet the programme delivery organisation requirements. These are illustrated in the case study below from the French nuclear industry.

Case study 3: **Dismantling of an experimental reactor in France – example of retraining the operating personnel, including developing an "intelligent customer" capability**

The shutdown of the reactor was accompanied by significant changes in the organisation of the facility and consequently a redefinition of different functions. In particular, it should be noted there was a:

- transition from an organisation structured by functions and job specialties (electricians, mechanics, etc.) to one structured by objectives (dismantling works, maintenance management, waste management);
- transition from a culture of "doing" (maintenance and works) to a culture of "getting it done" (writing contracts, oversight of subcontractors) for a large number of functions;
- fusion of the maintenance department with the operating teams in order to develop the versatility of the employees.

The role of maintenance personnel evolved to include contract management of subcontractor companies (expression of expectations and needs in the contracts, site supervision). Maintenance personnel (mechanics, electricians, etc.) have also become operations and contract managers.

To support this change, staff have undergone a specific skills management process based on dedicated training, which has been evaluated. The main training is made up of three modules ("needs analysis and specifications", "start-up, monitoring and supervision of subcontracted activities", "oversight of subcontractors") whose general objectives include being able to monitor and control decommissioning operations and know how to master the development of technical specifications. A specific professional authorisation for operations supervisor status has also been put in place for the personnel who are required to co-ordinate activities carried out by subcontractors on the facility. In addition, the head of the facility received dismantling training before the final shutdown of the installation so as to work with his teams on preparing for dismantling during the shutdown phase of the installation. This included definition of the strategy and preliminary scenarios, including realisation of preliminary operations of dismantling.

These measures put in place by the operator following the shutdown of the reactor made it possible to ensure, under satisfactory conditions and by using a specific skills management approach, the retraining of the maintenance staff into operations supervisors and contract managers. This shift from "doing" to "getting it done" presupposes the competence of the staff to be able to maintain control on safety issues, in particular thanks to a regular presence in the operations field. In order to reduce the administrative burden arising from the large number of contracts, the operator uses a consolidated contract (electrical, mechanical, furniture). The outcome sought is to maximise time in the field.

The experience of decommissioning of the UK Magnox stations showed that those who check that contractors are suitably qualified and who provide supervision in the field and a focus on safety are key to day-to-day success. It was found necessary to maintain sufficient people of the correct calibre without compromise and that their other tasks needed to be off-loaded from them to ensure they spent >80% of their time in the field. The broadening of skills was also identified as a positive aspect of the decommissioning of the Magnox fleet. For example, plant operators took on radiological monitoring roles, maintenance technicians were upskilled to undertake some engineering work, and multi-skilled teams were formed.

As experience with decommissioning work increases, it may not be viewed as challenging. However, even though it might not be the first time that some of the activities are performed, these activities should always be treated as "first time" tasks in a decommissioning environment. These activities need extra attention and need to be evaluated and planned for accordingly, especially with regard to radiation safety, which might have very different conditions between plants. Even though it might be the same type of equipment as at another plant, the radiation levels might differ and previous work procedures might not be suitable.

As the plant focus shifts to non-engineered safety of operations and activities, there is a continuing need for strict adherence to method statements and work instructions. In summary, conditioning and familiarity can serve as an error trap and the risks associated with each task need to be assessed in their own right and associated controls put in place. Approaches such as an infrequently performed task execution (IPTE) process or a critical task analysis that involve detailed planning, review and challenge meetings before the task is performed could be easily adapted for a decommissioning environment.

New construction projects are usually necessary during decommissioning, for which subcontracting firms are often required (for example, for civil engineering, metal structures, materials and mechanical and electrical). Access to this market requires companies in the sector to maintain and anticipate the resources and skills required. New challenges will arise during the management of complex projects and there will be technical innovation. Therefore, it is important that the necessary skills can be deployed by the operator and contracting organisations.

It is important to give visibility on the number and type of reactors to dismantle, and their scheduling. It is also essential to think of the mapping of the trades and associated skills in the long term by developing collaborative strategies with the stakeholders and subcontractors. Meeting these conditions would ensure that companies invest in the recruitment and professionalisation plans of their staff in order to allow them to acquire and maintain the required skills.

Effective collaboration is crucial, and contractors should be included in all day-to-day activities to ensure they feel part of the organisation – to create trust and to enable the licensee to shape behaviour. Likewise, it is important to encourage contractors to challenge work practices and behaviours, too. Effective collaborative working is a significant challenge but is crucial in setting and maintaining safety standards.

4.2. Effective leadership and governance

The IAEA states (IAEA, 2016b) in its *Leadership and Management for Safety* report that,

> 'Leadership' is the use of an individual's capabilities and competencies to give directions to individuals and groups and to influence their commitment to achieving the fundamental safety objective and to applying the fundamental safety principles, by means of shared goals, values and behaviour. 'Management' is a formal, authorized function for ensuring that an organisation operates efficiently, and that work is completed in accordance with plans and resources. Managers at all levels need to be leaders for safety.

Successfully navigating through periods of uncertainty and change requires inspirational leadership. Employees will be aware of proposals to shut down before detailed plans have developed regarding timing and how the defueling and decommissioning process will change work routines and staffing. Social skills and communication skills take precedence over technical expertise throughout periods of significant change, and this can prove a challenge for some senior managers.

Setting direction and building trust

With regard to the above, a relevant good practice identified is to ensure that the licensees' leadership programmes include training in these soft skills, such as communication, dialogue with personnel, the ability to motivate and engage staff, especially through periods of change and instability. Communication from senior managers needs to be transparent and honest so that leadership can build and establish trust. A successful example of this was a Chief Executive Officer who "opened up" different meetings and encouraged employees to participate if they wanted. The Chief Executive Officer did this to show that the management team did not have a hidden agenda. This approach was received very positively by the workforce.

Communicating news and engaging with staff should not be left with middle or front-line managers, and should not be propagated only by media. Senior management need to demonstrate leadership by being ready and able to hold meetings with staff to openly communicate the latest news about company strategies, plans, and policies and to give staff the opportunity to ask questions and voice concerns. Direct communication and engagement from senior management is key to showing respect for people and concern for their wellbeing. Listening to and addressing the concerns of staff is fundamental to building collaborative working relationships across the organisation. This needs to include the contractor workforce to unify towards a common goal and to encourage a collaborative safety culture. Engaging with staff representative groups is an effective way to demonstrate leadership commitment throughout the transition.

Besides communicating information about where the company is heading and how the decommissioning planning is going, etc., experience shows that employees are naturally concerned about their own future. Managers therefore need to plan time to talk regularly and honestly with their employees on this subject. The manager may have a relatively short period of time ahead of starting to transition towards decommissioning, and employees may accept that management does not know every

detail about the future of the organisation. However, staff understandably want information and answers as quickly as possible to questions such as "what will happen to me", "what work can I do here in the future", and "should I look for another job?" One way of building trust is to acknowledge unknowns and to discuss this openly. Staff will understand that nothing is being hidden from them.

It is important to acknowledge the "whole person", and not only his or her technical competence. It is important to understand what employees' aspirations are – whether they would seek to remain at the site if possible, welcome retraining, prefer redundancy, be prepared to move elsewhere in the company, etc. As far as possible, employers should seek to meet the aspirations of staff and there have been many instances where this has been achieved, with the majority of preferences being met. When talking with employees it is also important to be specific to individual employees as far as possible. While some employees will be worried about whether they will lose their job, others may be worried about future job content (what kind of job will they have, whether it will be interesting, and whether there will be opportunities to develop). If managers and leaders can communicate where the company is heading, and present a coherent vision of the future, with concrete examples, this will be helpful for their employees and, ultimately, to help ensure safer decommissioning.

The same leadership principles of transparency and honesty also apply in cases with lay-offs and potential redundancies. People are generally realistic and the results from a study with small scale interviews showed that even though the people initially preferred to work at the same company with approximately the same tasks, they later appreciated the honesty. Some people may prefer redundancy where it is linked to a redundancy package and they will be keen to understand the terms, including any potential pay-off. After getting the information that they were most likely to be laid-off, staff were also informed that the company wanted to keep them for a couple of years and to provide training during this period so that they would become more attractive to other employers.

A relevant good practice arose from the transition into defueling and decommissioning of the UK reactors. Senior management learnt to engage early and frequently. They used a variety of methods such as "site director briefings", bespoke "HR transition briefings", "tea and talk" and other informal discussion opportunities in the workplace – locker rooms, workshops, etc. Management learnt the need to be more available for unplanned and reactive 1:1s in addition to planned engagement. Ultimately it was about leaders and managers being visible and being prepared to learn about things they had not previously thought about to better understand what might be worrying staff.

From a regulatory perspective, it is important to assess how the licensee supports its leaders and managers in the process of developing these "social skills". Extra consideration in doing leadership assessments should be part of the oversight in times of uncertainty. The importance of leadership cannot be overestimated under those conditions. An investment in leaders and managers will most likely also have a positive effect on other areas, such as competence and culture of safety. Regulators and operators need to have effective communication lines in place at all organisational levels so that there is an effective and efficient flow of information between both parties.

Leaders should also be prepared and, if necessary, trained to be aware of and, as far as possible, manage tensions, conflicts, disengagement, and stress as they can have a negative impact on co-operation, communication and safe performance. Such issues are more likely to arise if there are more people competing for jobs than job offers, or due to dissatisfaction with work, poor management, poor information policy and general feelings of uncertainty.

Leading through change

In the case of a nuclear power plant there will be a significant shift in focus away from generating operations. The status of the generating teams therefore diminishes as it is no longer the priority activity and other departments, for example waste management, may become more important for the company. It is important that managers (and other persons) are aware of and are sensitive to this situation and understand the shift from operations and the changing priorities onsite. It is important to acknowledge the work that they have performed and that losing status in this case is not the result of doing a bad job.

It is also unlikely that all leaders and/or managers from the operational phase of the plant are suitable leaders/managers for the decommissioning phase (if the decommissioning is performed by the same licensee, otherwise even greater changes might occur). Existing management may struggle to adapt. A future plan for leaders/managers is as important as one for other employees.

The change from generation to decommissioning will also affect the regulators in their oversight. Depending on the country-specific condition (how many plants are closing down, organisational structure, etc.) the regulators themselves might need to make a parallel organisational change. If the regulators change, it can also be a strong signal for the licensee regarding the expectations that the regulator has. As the regulator spans a breadth of activities, the regulator can help provide learning opportunities and encourage new decommissioning licensees to interact with existing licensees.

A lesson learnt from the UK Magnox experience and other decommissioning activities is that as the nuclear hazard on site decreases (once the fuel has been safely removed), conventional hazards will increase. It is therefore important for leaders and managers to emphasise that safety does not just mean nuclear safety and that staff at all levels need to remain vigilant. A plant's condition (for example, effluent treatment) can deteriorate over time and the mind-set that it will be decommissioned or replaced with a more suitable plant in the future means money is not spent on the existing plant. This experience shows that there is an associated risk of acceptance of degradation in the plant conditions by regulators and operators and that this can lead to unsafe conditions. Active and authoritative internal regulation plays an important role in this regard by working with senior leaders and managers to ensure that standards are maintained.

It is important, especially with a new licensee, to establish strong internal regulation and find ways for leadership to accept and embrace the role of the internal regulation group and give it authority and status. Strong organisational and safety culture will facilitate this.

The time from the decision to shut down, as well as the reason behind the decision to shut down, may also have an impact on staff turnover. If the decision comes as a surprise, employees might feel as if the "psychological contract" with the company has been broken (i.e. trust is lost), and they may be more likely to look for other jobs. Whereas in a plant naturally approaching the end of its life, the employees are more likely to see it as a natural organic next step, and less of a surprise.

The attitude and mood conveyed by senior management will affect the motivation of staff before and during decommissioning and therefore also staff's attitudes towards remaining with the organisation or looking to leave. The management should convey a positive attitude towards decommissioning as a new phase in the plant's life cycle, as an interesting challenge that brings new and interesting work/tasks, and a potential opportunity for staff. Decommissioning should thus be presented as something new, the start of something, and not the end of the plant and the organisation.

Management system considerations – UK Magnox reactors OPEX

The IAEA's General Safety Requirement Part 2 (IAEA, 2016b) sets out that senior management shall be responsible for establishing, applying, sustaining and continuously improving a management system to ensure safety. The experience gained from the defueling and ongoing decommissioning of the UK Magnox reactors has been reviewed in order to provide potential management system lessons for other organisations embarking on their own transition away from generation. The lessons learnt are summarised below:

- Senior leadership need to set clear expectations of adherence to the existing management system during periods of increased risk during transition.
- The decommissioning organisation should consider whether a different management system is required for decommissioning compared to that used for operations, as decommissioning is very different to generating and new processes will be required. The management system may change in terms of the processes, roles, responsibilities, etc. but it would still have as its overriding principle that safety is of the utmost priority.
- The focus on conventional and radiological hazards will increase. Where there is a fleet-wide approach, care should be taken to protect generating stations from management system changes designed for a lower nuclear hazard facility.
- The decommissioning organisation should consider the potential value of a decommissioning safety handbook that would focus on industrial safety, be proportionate to the hazard on the site, and reflect the timescales involved in achieving key decommissioning milestones.
- Early planning is required to identify the documents and knowledge needed to be retained through different phases post-generation, specifically post-defueling and preparations for decommissioning and deconstruction. Document changes will be required to update operating procedures relating to generation.

- There is a risk of underestimating the task of revising safety documentation for transitioning to post-defueling operations. There may also be fewer staff working on site to manage the workload of multiple documentation changes.
- The review revealed that while original procedures had been reviewed and cut down to support defueling operations, they had become fragmented. To address this issue, a team was taken offline to completely rewrite the procedures and bring them up to a coherent and modern standard. The lesson was to not cut corners or underestimate this activity, and to ensure that procedures are not reviewed in isolation. Procedural reviews should include users and be developed and validated "in situ" to ensure that they accurately reflect the task.
- It is important to get internal oversight in assurance activities for key phases of safety management systems change as there needs to be an appropriate level of challenge in the review process and third-party independent review.
- Early regulatory engagement is also needed to test assurances and seek evidence that strategic plans are in place for the management of the transition and associated impacts on organisational capabilities, including how the integrated management system will be adapted to help ensure safe decommissioning.
- Safety governance needs to be reflected in the roles and responsibilities on-site along with clear accountabilities and authorities (R2A2s). This is also an important area for the regulator to test the arrangements put in place and to seek assurances.

4.3. Culture and motivation

Culture, or specifically culture for safety, is defined by the IAEA as "The assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance" (IAEA, 1991). The transition from generating operations to decommissioning is a massive change, during which time the organisation needs to maintain a healthy safety culture. During the generating phase, the focus on nuclear safety is paramount. As the transition to decommissioning progresses, the focus necessarily shifts towards radiation safety and occupational health and safety.

To be able to adapt accordingly, the discussions from the WGHOF Decommissioning Capabilities workshop clearly stated that the regulators expect the licensees to make risk-informed decisions on how safety culture is expected to be maintained and fostered through the various phases of decommissioning. It is important for both regulators and licensees to ensure a proportionate focus on relevant risks as the risk profile changes through the different phases. This is particularly important as there are invariably cost pressures associated with decommissioning activities which in turn can have an impact on safety culture. A culture for safety can be maintained via risk-informed decision making, a proportionate focus on dynamic risk, and a visible commitment to safety. Risk assessments need to be responsive to the changing nature of work activities as the decommissioning strategy progresses.

A complicating factor when decommissioning older reactors is that they may not have been built with a view to facilitating decommissioning. This needs to be taken into account in the decommissioning strategy and planning phases. The decommissioning organisation needs to take human factors into account in decommissioning task design so that conventional and radiation risks are controlled and managed systematically.

The Decommissioning Capabilities workshop discussions and the literature search and lessons learnt reviews also identified a number of good practices relevant to decommissioning. These include early regulatory involvement, building relationships with other regulators, and establishing a safety culture working group. The regulator should routinely and systematically observe the decommissioning organisation to identify the emergence of any issues in leadership and safety culture and take early and proportionate action if necessary.

Regulatory oversight of safety culture

A well-resourced and authoritative internal nuclear oversight function, together with employee representative groups, plays an important role in helping to ensure that the organisation is open and honest about the state of its safety culture. Early involvement is especially important if the decommissioning organisation will be a new licensee, or when the licensee is an intelligent customer overseeing a main decommissioning contractor. In many countries, the licensee in control of generating operations is not subsequently in control of decommissioning. The licensee responsible for decommissioning might be a new partner with less experience in safety management and regulatory interaction.

During the Decommissioning Capabilities workshop discussions, it was apparent that integrated regulatory inspections were not common. However, regulators who had done inspections together with other regulators fully recommended it, especially during decommissioning, where the risk profile changes from predominantly nuclear to more conventional and radiation safety. A co-operative approach when performing inspections is also recommended to decrease the risks of missing issues and to do a proper "hand-over". The workshop also identified that it is very valuable, especially for regulators, to meet the full range of employees and other stakeholders at all levels. Just interviewing managers or reviewing a safety programme document does not necessarily give a representative picture of safety culture.

Establishing a safety culture working group was also identified as a good practice. It should consist of representatives from the different groups involved in performing tasks and should be started in the preparatory stage where planning is carried out. The number of participants and the representatives will change during the decommissioning phase. The task and mandate of the group should be clear and cover fundamental aspects, including: monitoring safety culture; identifying risks to safety culture due to changing tasks; taking measures to improve safety culture; creating organisational, staff and contractor interfaces for safety culture. To be effective, this group must be heard by management and this is best achieved by ensuring that the group is included within the organisation's formal governance arrangements and is visible to the regulators.

Managing uncertainty – people

Experience shows that decommissioning is a period of great uncertainty and unease for staff and management; the plant loses its mission and staff lose their primary function. People can find it difficult to adjust to a "shutdown" working environment and this can affect work motivation. This is important both during the time from the shutdown decision until final operation, and throughout the transition and dismantling. In the first case, it is important to maintain motivation and quality in work.

The rationale behind the shutdown decision can affect staff motivation and therefore how decommissioning is approached. To counter this, the Decommissioning Capabilities workshop highlighted the positive impact of a clear company vision and a long-term plan, helping employees see how their work contributes to the overall goal. This was discussed in Section 4.2 of this report and is restated here because of the importance of a vision and strategic direction to staff motivation. The French case study (presented in Section 4.1) identifies a psychological impact whereby the operator has the feeling of deconstructing what they have helped to create and maintain for many years.

In any phase of the reactor, from generation through to decommissioning, staff need to feel valued, with a sense of pride in what they contribute. Staff need to be strategically informed on the direction of the facility as uncertainty is a source of stress. This, combined with potential demotivation, can lead to degraded safety performance, which must be guarded against. Work planning and task management designed with good staff engagement are also important aspects in helping to ensure staff motivation during the transition from generating through to decommissioning.

Case study 4: **Canadian National Research Universal (NRU) research reactor**

A valuable approach that was identified from operating experience from different decommissioned facilities is to have a closing ceremony to acknowledge the work that has been performed and the people behind it. For example, at a research reactor in Canada a video was produced that told the story of the facility, the people who had worked there, the advantages obtained from the science performed, and the activities carried out in connection with the closure.

The video was appreciated and created a feeling of value and belonging along with a celebratory closing ceremony. See CNL, 2018 for links to the video.

Culture and motivation – UK Magnox reactors' OPEX

The experience gained from the defueling and ongoing decommissioning of the UK Magnox reactors has been reviewed to provide culture and motivation lessons for other organisations embarking on their own transition away from generation. This learning is summarised below:

- There is a big change in culture on the site once the reactors stop operating – the site changes from being a production-driven generating site to project work that is focused on delivering decommissioning milestones. There are significant changes to the way work is managed, and the number and skill sets of staff on site.
- The site has a successful operational record with a clear focus on safe generation. People naturally like the status quo, so changing to a decommissioning culture is difficult and existing management may struggle to adapt. Sustained inspirational leadership is key to ensuring that people transition effectively and remain motivated. A vision used for one site was to be in as good a condition on the last day of generating electricity as it was on the first. This is a simple but effective vision and sets the tone for standards and expectations.
- The attitudes and behaviours of staff during this transition are a key consideration as the massive change will have a psychological effect. Staff performance should be monitored, and incentives should reflect this and include an appropriate focus on behaviour and culture.
- It is important to manage the change in approach as the risk profile of the site changes (i.e. the change from predominantly nuclear hazard to a more conventional hazard). The approach should be in line with decommissioning tasks as opposed to more steady state operations.
- Delays in determining options for staff can create uncertainty and impact morale and motivation. Where there are delays, senior management need to maintain active dialogue and open staff engagement to prevent uncertainty and to help ensure that attitudes to safety do not degrade.
- There is a natural risk of a dip in staff morale at the end of defueling activities due to changes in staff structures. To counter this, staff must be involved from the outset of the change process. It is important to identify staff who will go on the full decommissioning journey with the organisation and those who will not, and to manage different staff groups accordingly but under one overall strategic direction.
- Event reporting must be maintained throughout the transition to support a fair and just culture and to learn lessons for sharing. The reporting must include contractor groups, so event report processes need to be simple, effective and efficient.
- Asset management can play an important part in maintaining the right culture. This includes welfare assets such as offices, toilets, showers, rest areas, etc. Degraded conditions in these areas can have a negative motivational impact and lead to a degradation in working standards and expectations.

4.4. Effective programme and project management

Decommissioning strategy

In its decommissioning strategy, the operator may adopt a programme approach, i.e. a group of related projects managed in a co-ordinated way to obtain benefits and control not available from managing them individually. This is to use funding and resources in the most efficient manner and to help define and achieve business outcomes. Projects are usually created for specific deliverables.

During the decommissioning of an installation, the needs in terms of management and conduct of projects evolve with the progress of the phases of the decommissioning programme. This requires anticipating the need for advance and long-term strategic planning, including analysis of different scenarios and their associated risks and resources. Planning should take place at an appropriate level of detail given the long-term nature of the work and the number of unknowns.

For a generating site, changing from an operations focus to a project management focus means that whereas the site used to ultimately support the reactor control room, in decommissioning, everyone supports the projects. This is one of the main changes. Focus must be maintained on long-term projects and achieving key decommissioning milestones – achieved in the short-term through smaller scale, quick-turnaround projects – while ensuring safety and compliance.

A safety case for decommissioning should be developed for the new post-operation/post-defueling phase of the life cycle to reflect the reduction in hazard at the plant. The safety case (or the decision to have several safety cases) depends on the decommissioning strategy, the phases identified in the planning, and time. For example, a decommissioning process stretched out in time may have a safety case for the first period of time and another safety case when the radiation has decayed. The regulator and the licensee need to have an open dialogue on the development of the safety case. Operating rules will need to be revised to remain fit for purpose and appropriate for the phase of the plant lifecycle. Maintenance schedules will need to be reviewed as some systems, structures and components (SSC) in the plant may be redundant and may not need to be maintained to the same standards as they were when operational. Conversely, some SSCs may have greater requirements on them during decommissioning, for example cranes for waste retrieval, or ventilation systems, and therefore the maintenance requirements should be reviewed to ensure they are still appropriate. Preparations for entry into a quiescent state will involve the construction of facilities to enable decommissioning, e.g. waste processing facilities and stores.

From a regulatory perspective, a good practice is to ask specific questions on how the licensee prioritises its activities using its risk assessment process and if this is updated regularly. For example, is the licensee's reasoning based on relevant risk analyses and is it well-grounded? It is therefore important to focus on the relevant safety aspects and the associated safety case.

To ensure adequate control, the project organisation must co-ordinate the requirements of the licensee's organisation, its engineering functions (including contractors), and various stakeholders. The interfaces are numerous and their management is complex in order to allow everyone involved to focus on safety issues.

As mentioned in Section 4.3, changes may also be needed to the arrangements for co-operation with other regulatory bodies. Starting this co-operation early would be beneficial to understand each other's responsibilities, agenda and priorities. It is important to identify the interfaces and ensure that nothing is missed.

Programme and project governance

Governance arrangements must be robust. Experience has shown that roles, responsibilities, authorities and accountabilities (R2A2s) for overall programme management must be clear, e.g. programme directors providing a single point of accountability and the same principle applying to supporting projects. Programme management arrangements may be needed. The approach must be linked across programmes and projects with a simple and agile integration process that identifies major safety and cost lessons and disseminates them rapidly.

The first and probably most important aspect is to ensure that people responsible for decommissioning planning and the project management are competent. The qualifications and skills should be identified, and the project team set up with these competencies. As previously discussed, (Section 4.1) project management experience and ability may not exist in the current management. The Licensee's Design Authority (responsible for maintaining the knowledge base in order to maintain the design integrity over time), should be kept close to the work and involved in approving designs where appropriate. Similarly, it is also a good practice to embed a Chief Engineer into significant projects.

A risk regarding decommissioning is that it is expected to be performed under high economic pressure in a "value for money" environment. It is important to understand how work programmes might be incentivised and how performance might be measured. For example, is the operator incentivised by measures related to hazard and waste reduction or by measures related to schedule and cost performance alone? The latter may encourage perverse incentives while the former should drive appropriate safety-related behaviour and allow the strategy to be delivered effectively and safely – while recognising this cannot be at any cost. In summary, it is important to construct incentive schemes carefully to encourage the right behaviour.

Regulatory involvement may vary depending on the level of experience of the licensee undertaking decommissioning. If the licensee is a former operator or a company that has performed several other decommissioning projects, they are more likely to appreciate the scale of the task and the regulatory body and licensee probably know each other. Overall regulatory involvement should be targeted and proportionate.

The decommissioning organisation should align with the principles of a learning organisation and actively pursue relevant operating experience. There are opportunities throughout the transition from operations to decommissioning for learning from OPEX, e.g. safety, project learning, near misses, new ideas and opportunities for improvement, and good management practices. Licensees with a number of facilities entering decommissioning need to consider how learning can be passed onto stations as they move into different phases of the lifecycle. Mistakes made in decommissioning the first reactor must not be repeated in subsequent reactors.

Case study 5: **"Lead and learn" approach in UK Magnox reactor decommissioning**

A "lead and learn" approach was used to inform and optimise the decommissioning of the UK Magnox reactors.

The complexity of the proposed clean-up was amplified by the fact that most facilities, such as the Magnox reactors in the United Kingdom, were "one-off" designs. Ongoing design modifications and construction methods meant that each new station was slightly more refined and different from the previous model. The lead decommissioning station(s) shared learning with those identified as next in line. Following completion of projects there were opportunities to review, challenge, learn and improve/make fit-for-purpose.

Activities to capture the lessons learnt were built into programme schedules. This enabled other stations to learn from some of the earlier practices during the transition to defueling. These lessons included:

- Identify tools and techniques for assessing the likely "supply and demand" for skills and knowledge and develop appropriate resource management strategies.
- Adopt similar organisational structures and governance arrangements to those that have proved to work effectively.
- Optimise maintenance requirements.

More recently, the UK Nuclear Decommissioning Authority (NDA), which has responsibility for providing a clear and unified approach to decommissioning of the United Kingdom's first generation nuclear (and other) sites, has developed its own "lead and learn" strategy and accelerated decommissioning at Bradwell, which has now entered its "care and maintenance" phase, while decommissioning at Trawsfynydd is now being accelerated. Innovations and off-the-shelf equipment from outside the nuclear industry are being introduced, where feasible.

Lessons learnt at Bradwell and Trawsfynydd will eventually be applied across the range of Magnox reactors in the United Kingdom.

"Lead and learn" is judged to be a highly effective approach throughout all transition, defueling and decommissioning lifecycle phases.

Working with the supply chain

The licensee will need to decide on the balance between existing staff and bringing in specialists both in project management and in specific work packages (as discussed in Section 4.1). During decommissioning, licensees will need to rely on the supply chain and the number of suppliers, as well as tiers of suppliers, might increase compared to previous experience. Today, some countries choose to limit the number of tiers of suppliers.

Case study 6: **Programme approach and working with the supply chain**

The UK Nuclear Decommissioning Authority (NDA, 2021) is a single contracting organisation for implementing a national integrated strategy consisting of an incentivised, three-tiered contractor and supply chain management programme to conduct clean-up of its sites.

Under its Magnox Optimised Decommissioning Programme (MODP):

Tier 1: The sites are operated by site licence companies (SLCs) under contract to the NDA. The SLCs hold the nuclear site licences and are responsible for day-to-day operations and delivery of site programmes.

Tier 2: Tier 2 suppliers work directly with the Tier 1 SLC and subcontract to Tier 3 and below. Services include designing and manufacturing specialised equipment and construction.

Tier 3: Lower-tier companies fill certain niche requirements. Certain Tier 3 suppliers have worked across multiple SLCs, including the Sellafield, Magnox and Dounreay sites. Some 2 000 suppliers support the UK Magnox reactors.

One significant benefit of the MODP is the grouping of common strategic programmes to bring resources and expertise to address the same core technical and organisational challenges across the UK Magnox reactors.

To maintain transparency, the NDA is accountable to the public and the UK government. Milestones are established to monitor progress against clearly defined endpoints.

Management of the supply chain will be crucial and there is a need to assess and mitigate the impact of supply chain availability on project delivery. A fundamental principle is that risk cannot be outsourced so there must be sufficient capability to manage the supply chain within the licensee organisation. Therefore, it is most important to develop "customer intelligence". It is difficult to be an "intelligent customer" without knowledge and experience and many utilities do not have decommissioning experience.

Regulatory guidance both from the regulatory body and from the licensee's internal regulation function needs to address oversight of the supply chain and sharing experience between licensees and regulators will have a positive effect on that issue. As set out in the case study in Section 4.2, the licensee should develop a management system that suppliers need to adhere to or evaluate the supplier's management system and assess whether it meets the requirements. The key issue is that the licensee may need to perform oversight of its suppliers to a greater extent than today, which might also affect organisation and competency requirements throughout the decommissioning programme. The regulator will expect to see evidence of supply chain management and intelligent customer capability.

The supply chain itself may not have an in-depth understanding of the licensee at the outset. There is a need to target specialist decommissioning project contractors to understand their capability, draw on their expertise and build relationships early. Experience shows that this relationship can develop by starting small (e.g. call-off contracts) and, as learning develops on each side, the scale of contracts can be stepped up or down incrementally as necessary. This helps to identify those in the supply

chain who will be crucial to success. It also helps to mitigate against "optimism bias", where contract organisations are driven to bid for work only to find they cannot deliver for a variety of possible reasons.

The procurement process needs to be an integral part of the licensee's intelligent customer capability and rigorous optioneering processes are needed to identify the best contractor. The licensee should ensure that suppliers:

- have the organisational and technical capability, capacity and culture to deliver items or services to the required specification;
- have appropriate quality management arrangements that are consistent with the safety significance of the procured items or services;
- conduct effective oversight and assurance of the supply chain, including acceptance of items or services for work with nuclear safety significance.

It may be that availability of contract resources will be required to support activities across a number of sites. For example, the end of generation may occur in quick succession across sites, so the licensee may need to develop a multi-site programme and consider what opportunities there are for learning, for transferring successful technologies between sites and transferring personnel. For reactors, management of spares and identification and management of obsolescence are areas where close work with the supply chain will be required. For example, the charging machine (the machine used to remove and replace fuel assemblies) will need to operate for a long time – not just for defueling – and plug units will still need to be removed.

Managing uncertainty – Contract management

France has a range of fuel cycle facilities including laboratories, factories, waste treatment facilities, waste storage facilities, etc., of different size and with a diversity of nuclear wastes. In each case of dismantling, there are many actors and stakeholders, including external actors (government, legislator, safety authority, national agency for waste management, public [local/national, including opponents], industrial partners and internal actors [executive management, finance directors, communication, production and engineering management]). Planning the dismantling of these facilities is often difficult to manage because of the complex regulatory framework including lengthy assessment and appeals processes and periodic stopping points in the dismantling process required by the safety authority. Moreover, uncertainties such as the lack of input data about the state of the facility (type of historical waste, for example) makes management of these projects more difficult, especially in a contract-led environment.

To reduce uncertainty, it is important to consider the following:

- Optimise knowledge of the installation before its dismantling: development of a comprehensive inventory of structures and wastes will be crucial.
- Optimise the task specifications required from the industrial partners who will carry out the work.

- Focus on specification of functional requirements in contracts, i.e. the outcomes rather than the means (and rethink the means as the project progresses), which also makes it possible to promote innovation.
- Ensure that contract organisations are delivering appropriate safety cases before specialist equipment is designed and procured to ensure the appropriate level of safety is designed in from the start.
- Encourage robust dialogue with contractors to clarify requirements and improve specifications prior to contract letting and minimise costly scope change. Scope change can escalate and cause considerable delays and extra costs.

Case study 7: **Decommissioning of nuclear waste storage pools in France**

The nuclear installation referred to in this case study was commissioned in 1964.

In 1992, the licensee decided to take back the fuels stored in the storage pools for processing.

In 2004, the safety authority issued the authorisation for decommissioning the pools.

In 2005, dose rate measurements carried out in the storage pools revealed the existence of "hot spots" at the bottom of one pool. Following an unannounced inspection, the safety authority asked the licensee for additional information on the results of investigations into the origin of the “hot spots”.

In 2007, the “call for tenders” for decommissioning of the storage pools was declared unsuccessful. The main difficulty encountered by the contractors was the inability to meet the licensee's requirements resulting from the uncertainty about the initial state of the facility.

In 2008 and 2009, the licensee carried out a detailed physical, radiological and waste inventory of the facility, making it possible to specify the initial state.

In 2011, the licensee launched a new call for tenders on the basis of the new input data.

A contract was signed in 2013. Six months later, faced with implementation difficulties, the contractor asked the licensee to review the contract. Operations were temporarily stopped. The schedule proposed by the contractor did not take into account certain technical uncertainties, so it became obsolete. At the end of 2013, the contract was terminated by the licensee for non-compliance with contractual commitments.

In 2015, the licensee proposed an alternative scenario with a contractor that had good knowledge of the facility. Decommissioning of the pools was finalised in 2018 (14 years after authorisation by the safety authority).

This case shows that the initial contractual frameworks seemed insufficient to manage uncertainties linked to the preparation and execution of D&D works. In other words, the uncertainty relating to the decommissioning of facilities was not taken into account sufficiently in the definition of regulatory requirements and in the management strategies of decommissioning projects.

A contract is incomplete when it cannot specify sufficient detail of the work to be undertaken. An uncertain project necessarily leads to an incomplete contract, which can lead to the following:

- “Adverse selection”: the licensee chooses the lowest financial offer from the different contractors, some of whom may have shown optimism bias in putting forward their bid in order to secure the contract.

- "Hold-up" strategies: the contractor uses situations of dependence to renegotiate the contract to their advantage. In this case, uncertainties are re-exploited by the subcontractor during the contract. This often leads to consequences such as:
  - An increase in dismantling durations (cancellation of a call for tenders, temporary work suspension, renegotiation of contracts).
  - An increase in associated costs, both for licensees and contractors (cost linked to the demobilisation of staff, compensation in the event of breach of contracts).
  - A demobilisation and demotivation of staff with, in some cases, a deterioration of the social climate/safety culture.
  - A loss of skills and loss of knowledge.

Chapter 5. Good practices for licensees to overcome HOF challenges

Below are some of the good practices identified for licensees to help overcome HOF challenges associated with transitioning from generating operations through the various phases of decommissioning and dismantling (D&D). These are presented for each of the four components set out in Chapter 4 that underpin organisational capabilities for decommissioning.

Capable and competent workforce

- Early engagement (prior to formal submittal of an application) is vital to understand the regulatory framework, regulatory expectations, and the processes for obtaining any regulatory approvals.
- There should be an overarching strategy for the management of capability on the site. Develop a clear company vision and a long-term plan in line with it, letting employees see how their work contributes to the overall goal.
- Map the required critical competencies. Identify individuals with unique specialised knowledge who are vital to managing specific risks. Where possible, resilience should be increased.
- Recognise that the regulator will probably need to see a detailed justification for organisational structures and resource levels for significant change proposals.
- Develop future job profiles to show what challenges need to be addressed and what types of tasks will exist in the forthcoming decommissioning stages.
- Clearly specify training requirements for decommissioning activities.
- Develop the skills of programme managers early to meet the programme delivery organisation requirements.
- To maintain competencies, use incentives, address motivational aspects, and support leaders to actively engage personnel.
- Track staff turnover and evaluate the activities performed to ensure that enough (critical) competence remains within the company.
- Develop arrangements for maintaining an "intelligent customer" capability to ensure an effective interface with the supply chain that will be used to support decommissioning.
- Perform exit interviews to understand why people are leaving.
- Knowledge capture interviews can be really useful – for example, what went where? What was done when?

- Try to stay in touch with key people after they have retired, if they are willing – this has proved to be valuable as a component of mitigating the risk of knowledge loss.
- Perform leadership assessments to ensure that leaders have the proper skill set for times of uncertainty.
- Ensure that leadership programmes include training in soft skills, e.g. communication, dialogue with personnel, ability to motivate and engage staff.
- Talk regularly with employees and discuss their future; be transparent, honest and specific.

Effective leadership and governance

- Ensure that leadership programmes include training in soft skills, e.g. communication, dialogue with personnel, ability to motivate and engage staff, especially through periods of change and instability.
- Communication from senior managers needs to be transparent and honest so that leadership can build and establish trust throughout the organisation and with the supply chain.
- Direct communication and engagement from senior management is key to showing respect for people and concern for their wellbeing at all levels.
- Engaging with staff representative groups is an effective way to demonstrate leadership commitment throughout the transition, and to hear and encourage challenges.
- When talking with employees, it is important to be specific to individual employees as far as possible.
- Leaders should be prepared, and if necessary trained, to be aware of and help manage stress, which can hurt safety performance.
- A future plan for leaders/managers is as important as one for other employees.
- Senior management should convey a positive attitude towards decommissioning as a new phase in the plant's life cycle, as an interesting challenge that brings new and interesting work/tasks, and as a potential opportunity for staff.
- Have the internal regulation role in place from the beginning of the decommissioning phases.
- Consider whether the management system needs to be adapted to decommissioning compared to that used for generation operations.
- Develop a management system in which suppliers adhere to the same requirements or evaluate the supplier's management system and assess if it meets necessary requirements.
- Early planning is required to identify the documents and knowledge that needs to be retained through different post-generation phases.
- Procedural reviews should include users and be developed and validated "in situ" to ensure they accurately reflect the task.
- Safety governance needs to be reflected in the roles and responsibilities on site, along with clear accountabilities and authorities (R2A2s).

Culture and motivation

- During the generating phase, the focus on nuclear safety is paramount. As decommissioning progresses, the focus shifts towards radiation safety and occupational health and safety, which brings an associated need for training and competence in these areas.
- Take human factors into account in decommissioning task design so that conventional and radiation risks are controlled and managed dynamically.
- Make effective use of the internal regulatory function and staff representative groups to inform a balanced perspective on safety culture and staff motivation.
- At the start of the decommissioning planning stages, establish a safety culture working group including representatives from the different work groups. Ensure that the group is included within the organisation's formal governance arrangements, and is visible to the regulators.
- Strategically inform staff on the direction of the facility as uncertainty is a source of stress which can lead to degraded safety performance.
- Plan work and task management with good staff engagement to ensure staff motivation during the transition from generating to decommissioning.
- Acknowledge the work completed and staff contributions as each phase concludes.
- To counter any drop in morale as generation stops, involve staff from the outset of the change process and identify staff who will go on the full decommissioning journey with the organisation and those who will not.
- Maintain effective event reporting throughout all the transitions and ensure that contractors are also involved with this.
- Ensure that staff welfare is maintained and not degraded during the transitions. This extends to maintaining facilities such as offices, restrooms, showers.

Effective programme and project management

- Timely notification ensures the regulators' involvement into the process of change.
- Start planning as early as possible. Consideration of human and organisational factors will provide benefits if included early in the planning process. In particular:
  - have a clear concept of the decommissioning process, strategy and its major activities;
  - divide the work into phases;
  - specify goals for each phase;
  - set up regular meetings where progress will be followed (according to plans and goals).
- Have an open dialogue with the regulator on the development of the safety case and identification of a relevant risk profile.

- The licensee needs to be an intelligent customer with regard to their contractors, but they also need to monitor and perform oversight to ensure smooth progress around an intelligent customer.
- Develop an understanding of business and future requirements with the supply chain.
- Ensure that enough budget is reserved for decommissioning, noting that some regulatory regimes provide financial guarantees.
- Consider whether a "lead and learn" approach might work or identify other sources of OPEX for decommissioning.
- Consider how work programmes might be incentivised and how performance might be measured, e.g. prioritising hazard and waste reduction, while ensuring that incentives drive the correct behaviour.

Chapter 6. Good practices for regulators to overcome HOF challenges

Below are some of the good practices identified for regulators to help overcome HOF challenges associated with transitioning from operations through the various phases of decommissioning and dismantling (D&D). These are again presented for each of the four components set out in Chapter 4 that underpin organisational capabilities for decommissioning.

Capable and competent workforce

- Require the licensees to plan for organisational staffing for all the phases, from the transition through to the decommissioning organisation. Does the licensee appreciate the scale of the task?
- Review how the licensee manages capability and future resilience. Evaluate the activities performed to ensure that enough (critical) competence remains within the company.
- Verify how licensees have mapped the critical competencies.
- Assess how the licensee is managing organisational change to minimise risks to nuclear safety.
- Consider how the licensee's internal regulatory function is providing oversight and challenge. Do they have a credible and resourced plan?
- Regulators may need to make organisational changes associated with licensee organisational changes during decommissioning. Consider the benefits of multidisciplinary teams to assess organisational change proposals, e.g. in engineering and maintenance capability.
- The regulatory body should also ensure that there is an appropriate transfer of knowledge and information on asset conditions within its own organisation. Consider the continuity of inspectors and assessors. Otherwise this could lead to knowledge/experience problems and inefficiencies in regulation.
- Consider the balance of knowledge and experience on an inspection/assessment team, e.g. in terms of knowledge and experience of the site when it was operating and knowledge and experience of decommissioning sites and activities.

Effective leadership and governance

- Advise that the licensees' leadership programmes include training in soft skills, e.g. communication, dialogue with personnel, ability to motivate and engage staff.
- Assess how licensees support their leaders and managers in the process of developing the above soft skills.
- The regulator and the licensee need to have an open dialogue in relation to the development of the safety case and identification of a relevant risk profile.
- Encourage new decommissioning licensees to interact with existing licensees, particularly those that have performed or are performing decommissioning.
- Actively encourage the role of the internal regulator within the decommissioning organisation in support of effective self-regulation.
- Promote the role of internal oversight to the licensee senior management and leadership.

Culture and motivation

- Routinely and systematically observe the decommissioning organisation to identify any issues in leadership and safety culture and take early and proportionate action if necessary.
- Meet the full range of employees and other stakeholders at all levels as just interviewing managers or reviewing a safety programme document in isolation does not give a representative picture of safety culture.
- Work coherently with other regulators where possible to ensure a targeted and proportionate approach and to ensure that overlaps and gaps are avoided.
- Actively encourage the role of the safety culture working group by engaging with it and promoting it to senior management.
- Engage with staff representative groups to test for strategic alignment and motivation.
- Reinforce the need and importance of event reporting throughout the transition to ensure that lessons are learnt by all stakeholders efficiently and acted upon effectively.

Effective programme and project management

- Evaluate the licensee's overall decommissioning strategy and look for evidence that HOF issues are recognised and addressed (e.g. they are delivered through other policies and processes).
- Seek evidence of the licensee's supply chain management and intelligent customer capability.
- Regulatory guidance needs to address oversight of the supply chain.
- Consider how the licensee is developing its contractor oversight and whether regulatory programme needs to change.
- To improve customer intelligence, share experience between licensees and regulators.
- Start co-operation early among the other regulatory bodies required during the decommissioning process to understand each other's responsibilities, agendas and priorities.
- Where appropriate, perform inspections jointly with other regulatory bodies (e.g. the regulatory bodies that protect against radiation safety may be different than those that take care of occupational health and safety). Environmental safety may also be subject to a different regulatory framework. Co-operative inspections decrease the risks of missing issues and ensure proper "hand-overs".
- Ensure that enough budget is reserved for the decommissioning, noting that some regulatory regimes provide financial guarantees.

Chapter 7. Conclusions

Human and organisational factors (HOF) should not be treated as a side task during decommissioning. To ensure proper plant and personnel safety, there needs to be a systematic approach planned and integrated into all aspects and all phases of decommissioning.

It is especially important to include HOF in the hazard, risk assessment and safety cases to be able to make risk-informed decisions and have a good sense of where and when human and organisational factors need to be addressed and to what extent.

This report addresses the safety challenges in decommissioning, the phases of decommissioning, and the human and organisational challenges associated with the transition from generating operations to decommissioning.

The report identified the four areas of key organisational capabilities for decommissioning and presented and described them as a coherent framework in Chapter 4:

- capable and competent workforce;
- effective leadership and governance;
- ability to manage culture and motivation;
- effective programme and project management.

In Chapters 5 and 6, this report summarised good practices for licensees and regulators, respectively, to overcome these HOF challenges and to help ensure safety throughout the decommissioning process.

As nuclear decommissioning activities expand globally, the potential to gather and make effective use of operating experience in this area also expands. This report is a contribution to that effort and can be used as a component of self-assessment for operators and regulators to help ensure effective, efficient and safe decommissioning activities.

References

ASN (2020), *Sécurisation du financement des charges nucléaires de long terme : l'ASN rend son avis sur les rapports des exploitants*, www.asn.fr/l-asn-informe/actualites/securisation-du-financement-des-charges-nucleaires-de-long-terme.

CNL (2018), Closure of NRU Research Reactor, retrieved from YouTube, www.youtube.com/watch?v=aZLzJqVN_0M, Canadian Nuclear Laboratories.

IAEA (2018), *Regulatory Oversight of Human and Organisational Factors for Safety of Nuclear Installations*, IAEA-TECDOC-1846, International Atomic Energy Agency, Vienna, www.iaea.org/publications/12349/regulatory-oversight-of-human-and-organizational-factors-for-safety-of-nuclear-installations.

IAEA (2016a), *Governmental, Legal and Regulatory Framework for Safety*, IAEA General Safety Requirements, No. GSR Part 1, International Atomic Energy Agency, Vienna, www.iaea.org/publications/10883/governmental-legal-and-regulatory-framework-for-safety.

IAEA (2016b), *Leadership and Management for Safety*, IAEA General Safety Requirements, No. GSR Part 2, International Atomic Energy Agency, Vienna, www.iaea.org/publications/11070/leadership-and-management-for-safety.

IAEA (1991), *Safety Culture: A Report by the International Nuclear Safety Advisory Group*, Safety Series No. 75-INSAG-4, International Atomic Energy Agency, Vienna, www.iaea.org/publications/3753/safety-culture.

NDA (2021), Home page, www.gov.uk/government/organisations/nuclear-decommissioning-authority (retrieved on 30 November 2021).

NEA (2018), *Preparing for Decommissioning During Operation and After Final Shutdown*, OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_15058/preparing-for-decommissioning-during-operation-and-after-final-shutdown.

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Organisational Capabilities for Decommissioning Nuclear Installations

The transition from nuclear power generation to decommissioning carries a number of safety challenges tied to human and organisational factors. This report discusses these challenges and brings together the experiences of members of the NEA Working Group on Human and Organisational Factors. It includes an overview and topical case studies from global decommissioning activities and sums up the good practices and lessons learnt to help organisations in their own endeavours to decommission nuclear installations.

This report can be used as a guide for self-assessment for both licensee organisations and regulatory bodies to manage the human and organisation factors in the various phases of their decommissioning activities.

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