ENISS
European Nuclear Installation Safety Standards

POSITION PAPER

Principles for developing the transition from operations to decommissioning

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Summary

This document provides the ENISS licensees' understanding of what is advisable when developing and implementing the transition from normal operations to decommissioning.

To develop this position paper, the experiences of the ENISS members have been collated and reviewed. The focus of this paper is on licensing and organisational change. Other areas of interest during the transition phase have been discussed but not developed here noting the availability of supporting documentation from other sources such as the International Atomic Energy Agency and the Nuclear Energy Agency for example. To communicate the common position, principles have been developed and summarised:

An agreed strategy is key for the transition from operations to decommissioning.

Principle 1: Strategic direction is provided by the licensee in order to prepare for the decommissioning of a nuclear facility.

Early preparation and engagement with internal and external stakeholders and suppliers are key.

Principle 2: Active preparation activities commence sufficiently ahead of the anticipated end of electricity production.

The licensee and regulatory strategies should take a proportionate and holistic approach based on the changing risk profile at the site. The nuclear risk and radiological hazard will reduce significantly following shutdown and removal of fuel from site, or removal of fuel to a dedicated interim spent fuel storage facility. Other hazards may evolve during some phases as decommissioning activities commence, e.g. labour safety.

Principle 3: The licensee engages early to develop an outcome focussed environment with key stakeholders including the regulator, in order to achieve a reasonably practicable and proportionate risk informed transition strategy.

There are significant organisational changes and challenges associated with the transition from operations to decommissioning, covering a broad range of areas from management systems, provision of suitably qualified and experienced personnel, to the management of the culture and morale during a period of great change and when the primary focus on safety must still be ensured. Preparations that begin early allow optimum organisational change and risk management.

Principle 4: Sufficient focus is given to the management of organisational change ahead of and during the transition period.

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1. Transition from operations to decommissioning - general introduction

The IAEA's Safety Report for 'Safety Considerations in the Transition from Operation to Decommissioning' (SRS No.36) states that "*the goal during the transition period is to achieve a significant reduction in radiological hazards through the safe termination of operational activities and removal of radioactive material, and to place the facility in a stable and safe condition until the decommissioning strategy is implemented. During this period, control of any remaining spent fuel, other radioactive material or nonradioactive hazardous material should be maintained, and the safety of the workers and the public, and protection of the environment, should be ensured*". The transition is also accompanied by significant organisational change to prepare for decommissioning.

Although IAEA SRS No.36 defines the transition period as the time from when a facility is permanently shut down until the decommissioning strategy begins to be implemented, it is more of a "meta-phase" that covers the end of the operation phase (several years before the shutdown, if the date is known) up to, and just beyond, the beginning of decommissioning, as shown schematically in Figure 1. It is advisable that some topics such as preparatory activities, organisational change, culture change, staff planning, etc. are addressed before the end of operation and they are completely part of the transition.

Figure 1: The transition period addressed by this position paper.

There are a relatively wide range of ways in which national strategies and legislation describe, licensees apply and regulators accept approaches to the transition from operation to decommissioning. There are clear and justifiable differences in approaches adopted in each country, which account for different factors such as: licensee/owner funding arrangements; national policy and regulatory frameworks; different reactor designs and status; availability of waste routes; and, other social and economic factors. Nevertheless, the IAEA goal for the transition remains well aligned across different member states.

This document gives a short overview about the ENISS licensee understanding of what is advisable when developing and implementing transition arrangements. It recognises and summarises existing standards and guidance specific to the transition period (Annex 1), and develops principles which focus on licensing and organisational change (Section 2).

2. Principles for a successful transition.

The following principles have been developed to complement standards and guidance summarised in Annex 1. These are based on ENISS members' experience focused on licensing and organisational change.

Principle 1: Strategic direction is provided by the licensee in order to prepare for the decommissioning of a nuclear facility.

It is preferable to have a clear agreed strategy for the transition from operations to decommissioning, driven from the top-level management of the licensee. This should be in place in good time (see principle 2) to allow alignment with internal and external stakeholders, and development of an appropriate regulatory interaction and decommissioning plan.

The transition from operations to decommissioning is a period of significant organisational and technical change. Changes to people, plant and processes should be aligned under the agreed strategy, and may be driven by a decommissioning plan. There are many internal and external factors that influence the setting of the strategic direction. A number of these factors may also result in changes to the strategy during the preparation or implementation of the transition, which require careful management to maintain alignment with stakeholders and manage changes to the decommissioning plan.

Factors that influence the strategy include (but are not limited to):

- Ownership and funding: Whilst the licensee typically owns the strategy and is responsible for the delivery of the plan, the funding arrangements may require other stakeholders to be consulted.
- National policy: National policy may influence many factors that drive the strategy, for example, the dates of end of electricity production, immediate or deferred dismantling, or the available routes for handling wastes.
- Regulatory framework and licensing: It is important to engage early with all relevant regulatory authorities, in order to converge on an agreed strategy and understand the regulatory expectations and approvals process.
- Facility design and status: The facility design and status will influence the method and timescales for the removal of radioactive material and other nonradioactive hazardous material.
- Waste led approaches: The development of an overall waste management strategy may be one of the first critical tasks in the strategic planning. Using a waste led decommissioning approach sets the scene for the further strategic and overall decommissioning planning. The strategy will be informed by the available routes for handling wastes.
- Available waste routes: Encompassing waste treatment and conditioning techniques available in the country or even abroad, waste interim storage, and waste disposal options. In some countries waste can be cleared after measurement, allowing for waste recycling or disposal by conventional means such as landfills, incineration, etc.
- End state: The end state may or may not have been fully developed or agreed at the point of transition. Nevertheless, the strategy should be informed by the end use of the site (e.g. 'green' field or 'brown' field, either of which may also be used for new nuclear site).
- Combinations of the above: A combination of factors will also influence the overall strategy. For example: the availability of waste routes combined with the site design and other factors such as national policy may determine whether an immediate versus deferred dismantling strategy is adopted.

- Other factors: Other technical or socio-economic factors may influence the strategy, for example the availability of suitable resources or the capacity (throughput) of waste routes (especially if there are multiple units undergoing transition). National and local stakeholders may also influence the preferred options.

Noting Principle 2 (preparations commence ahead of a planned shutdown), an early understanding of the factors that influence the strategy is helpful in order to guide the preparations.

Strategic decisions that drive the transition from operation to decommissioning include:-

- Corporate strategy: This sets out the direction of the organisation and the timescales for major milestones. This includes the possibility to hand over the installation and the licence to an external specialised decommissioning operator.
- People strategy: To maintain suitably experienced resources and manage the transition in numbers, knowledge and skills. To remove uncertainty from the organisation in order to manage expectations and morale.
- Organisational strategy: To set down the roles and responsibilities for the delivery of the transition and decommissioning plan.
- Regulatory strategy: To understand the expectations, engagement and approvals required by the relevant regulators.
- Technical strategies: These may cover the following areas:
    - Defueling and the removal of fuel related wastes.
    - Ongoing management of plant and infrastructure for its lifecycle.
    - Shutdown and isolation of redundant systems, and removal of any residual hazards.
    - Modifications to installations in order to ease dismantling activities and cope with the increased workforce.
    - Post-operational clean-up and decontamination activities.
    - Radioactive and non-radioactive materials and waste management, including clearance of wastes.
    - Dismantling activities permitted during transition.
    - Remediation and site clean-up.
    - Characterisation.
    - Preparations for decommissioning.
    - Changes to security and emergency planning arrangements.
    - Innovation, research and development and the choice of technology.
- Communication strategy: There are several aspects related to this area:
    - An overall strategy to manage internal, external, national and local stakeholders is advised.
    - Each of the above strategies may then have its own communications strategy.
    - Clear definitions and understanding of the different phases of operations, transition and decommissioning.

From the ENISS members' feedback and other sources the following experiences have been identified. This may help to plan a decommissioning project, although not all the experience given in this report is valid for all decommissiong projects, depending on local context:

- It is beneficial if the transition strategy is informed by the longer term national decommissioning strategy. A key element to decommissioning is around the availability of long term disposal routes for high, intermediate and low level wastes. This, in combination with factors influenced by the plant design, will inform the preferred approach (e.g. immediate dismantling vs deferred, fuel transferred off site or on-site interim storage, etc.). It is advisable to understand this at an early stage. Delays in decision making of a strategy for the storage of high and intermediate wastes have led to delays in the transition to decommissioning.
- It is beneficial to have decommissioning in mind from the outset, i.e. at the design stage, and to maintain this consideration during operation. This will provide the best opportunity to optimise waste streams and to avoid surprises or delays to decommissioning.
- In a number of countries there has been uncertainty over the closure dates, for example technical, political or economic issues have led to early closure of nuclear power plants. Without a clear understanding of the closure dates, or the risks of early closure, organisational change and the transition from an operational focussed business to a decommissioning focussed business can be delayed or inefficiently managed. This risk should be considered and mitigated by early preparation as far as reasonably practicable.
- In addition to the required sudden mindset change, the risk of early closure should also consider the waste route/disposal strategies. The absence of a plan or strategy could lead to major delays in the preparation phase, since decommissioning work may have to rely on limited interim storage facilities or similar interim arrangements.
- Understanding the release of waste from the nuclear power plant and limits for acceptance at waste facilities will set the scene for the decommissioning and waste management strategy. Difficult waste streams, or the non-availability of waste streams may lead to the decision to store on-site or build on-site management facilities. In some countries problems have been experienced with radioactive contaminated asbestos and tritiated waste streams, where the level of characterisation required for waste for release (even to recognised facilities) seems out of proportion to the safety/environmental benefit. The availability and capacity of transport, storage and waste processing facilities may be fundamental in setting the timescales for transition and subsequent decommissioning.
- In considering the availability and capacity of transport there are a number of factors. The available and licensed transportation ways and modes (by road, rail or even air in bigger countries) and the availability of licensed packages, whether they are licensed for transportation or storage, or dual purpose ones. Packages which are also licensed for final disposal may be of significant importance.
- Regarding waste processing facilities, the development and licensing process of both the installation and the treatment/conditioning processes plays an important role, and can result in significant delays, especially if new installations must be erected. Therefore, it is beneficial if the design studies and subsequent construction phase of those facilities are started with sufficient anticipation.

- Developing and discussing the decommissioning strategy with the main authorities (generally the nuclear safety authority and the waste management agency in most countries) in advance will give visibility of the decision making and allow aspects that are unacceptable or difficult to accept from the authorities' point of view to be identified and resolved. This approach paves the way for a smooth licensing process and enables the authorities to plan the associated workload and resources.

Principle 2: Active preparation activities commence sufficiently ahead of the anticipated end of electricity production.

Early active preparation is beneficial to understand and set the right strategies[1]. Preparation activities should then continue in order to deliver these strategies, noting that some elements may require many years to develop, permission and implement. There are also interactions with other Principles. For example, it is beneficial to understand which activities can be carried out under the operating licence, usually by the operating organisation, or which activities may require further regulatory permissions (Principle 3).

The transition preparation activities are wide ranging, including for example:

- licensing and safety documentation;
- organisational change (people, knowledge, leadership and culture, management systems, corporate structure, etc.);
- changes to the plant and its configuration;
- emergency planning arrangements;
- security;
- preparations for later stages of decommissioning;
- waste management; and so on.

These activities require significant levels of planning, with a good visible understanding of the interactions between the different areas. Early preparation for each of these activities, some years in advance of the scheduled shutdown or relicensing would be ideal. In particular, commencing early, ahead of a scheduled end of electricity production, can mitigate the inhibitors or risks of unexpected complexity or earlier than anticipated closure, all of which result in time pressure and potential delay to transition activities. However, it is acknowledged that early or unexpected closure of sites has occurred where it could not have been reasonably foreseen, and preparation activities were not complete.

The following section summarises key areas for early active preparation. Licensing and Organisational change are also important activities that require early active preparation, these are discussed under Principles 3 & 4.

Operational Fuel Management

There are both waste management reduction and commercial benefits from optimising the operational nuclear fuel management ahead of the end of electricity production. For example, in some cases fuel enrichments may be optimised for the final cycle(s). This may require preparation activities to commence several cycles ahead of the end of electricity production.

Where the end of electricity production date is subject to uncertainty, mitigations should be considered to avoid the receipt or loading of new fuel which would then not be used if generation was terminated. This is to avoid increasing the reactivity of the shutdown reactor and to minimise the risk of activation or contamination of the new fuel preventing or increasing the complexity of re-use elsewhere.

[1] It is a recognised that in some cases, preparations can commence a lot earlier, with design and operation with decommissioning in mind. The Principle presented in this paper is focussed on active preparations that are required to transform an organisation and prepare for implementation of the transition and decommissioning strategy.

Spent Fuel Management

The removal of spent fuel from a site will reduce the radiological inventory by more than 99%, significantly reducing the potential hazard and enabling major changes to the site to progress. As such, it is normally a focal point to carry out this activity safely with minimum delay during the transition period, due to the significant safety and commercial benefits to the site. The approach to spent fuel management also has a key role in defining the approach to other strategies, discussed later.

Spent fuel management options will depend on the available disposal routes, which will depend on national policies, available infrastructure and capacities of this infrastructure (e.g. storage and transport casks). This means that options may exist to send the spent fuel off site for reprocessing or disposal, or there may be off-site or on-site interim storage options, including dry storage casks or spent fuel pools (the 'spent fuel island' concept). The key objective is to achieve a safe segregation of the spent fuel from the decommissioning activities.

Preparation activities include:

- clearance of the new fuel receipt and fuel preparation facilities;
- unloading of the reactor and its impact on the plant (e.g. shutdown of redundant systems);
- emptying of ex-reactor facilities (e.g. buffer stores, dismantling facilities, ponds, etc.); and,
- handling and removal of damaged or failed fuel, which may require additional equipment or processes.

The timing of these activities are part of the spent fuel management strategy. For example, clearing facilities in advance may increase the capacity and throughput of spent fuel. Another preferred option may be to progress in parallel with, or following removal of spent fuel, to take advantage of any common work activities. Handling of damaged fuel may take place ahead of, or following removal of spent fuel, depending on a balance of safety and programme risks (i.e. a reduction in the decay heat and dose with time, risks to disruption of fuel handling facilities, etc.).

Spent fuel management activities are key to understanding the overall site transition strategy, and interact with many work areas. The spent fuel management strategy will interact with the organisational, people and plant strategies as certain areas of plant may require increased focus (e.g. fuel handling equipment and services) and other areas may become redundant. A good understanding of the spent fuel management strategy and the underlying site safety documentation is beneficial as early as possible.

The removal of nuclear fuel from site can allow a significant change in the status of the site. In some countries this also allows a change in focus of the regulation, with a reduced focus on nuclear legislation and an increased focus on environmental and radiological protection. Nuclear safeguards (i.e. EURATOM treaty) and security aspects may change in line with the change in the status of the site. The activities required to demonstrate a fuel free site or facilities should be considered early, as part of the spent fuel management strategy, as additional activities may be required to provide the agreed level of assurance. It is noted that even if the fuel were not removed from the site, but transferred to a separate facility at the same site might also have a similar effect, if the fuel storage operates independently at the site.

Plant Management

Management of the lifecycle of Systems, Structures and Components (SSCs) should be considered during the operational lifetime of the plant. Knowledge of the SSCs lifecycle, safety duty and environment will inform maintenance strategies and investment plans during operation, required to manage the SSCs throughout their lifecycle. For some SSCs this may go well beyond transition and into decommissioning.

During transition SSCs will fall into various categories, including:

- SSCs that are required during the transition and possibly beyond into later phases (e.g. handling equipment);
- SSCs that require modification or upgrading during the transition, either to meet the requirements of the transition strategy or to allow installation of simpler systems better aligned to the new post-shutdown conditions (e.g. ventilation systems);
- SSCs that are required during the transition, which may become critical to transition operations and require increased resilience (e.g. fuel handling equipment, spares and staff);
- SSCs required during operation, which are located within the facilities to be decommissioned, yet are shared with other facilities, that still remain in operation after shutdown;
- SSCs that become redundant during the transition; and,
- new SSCs required to facilitate waste management and decommissioning.

Key aspects for the plant management strategy to address include:-

- Maintaining alignment of the SSCs to the site safety documentation in order that the SSCs meet the requirements of the safety documentation at all times. The plant management strategy will be informed by the extant safety documentation and spent fuel management strategy. The plant management strategy may also influence the various safety analysis options. It is therefore possible that the development of these two areas will be iterative.
- Once the decommissioning date is understood, there may be a drive to pursue a more opportunist maintenance strategy rather than a conservative one, especially during outages prior to decommissioning. During this transition period additional controls may be appropriate in order to maintain the right level of maintenance in order to prevent a degradation in safety.
- Maintaining alignment with the knowledge and understanding of Operations, Engineering and Maintenance staff. During the transition period the potential for error could increase due to various factors, including an increased number of plant changes, non-standard operations and the change in focus of the site. Enhanced arrangements may be required to maintain plant status and configuration control. Records of changes should be kept using appropriate Product Lifecycle Management (PLM) tools. Increased numbers or re-assigned staff may be required to manage the sequencing of activities, changes to plant documentation (e.g. drawing, procedures), and changes to other nuclear power plant activities such as work management routines, maintenance strategy, etc.
- Consideration of the changing conditions. Ageing and obsolescence management should be aligned to the plant management strategy. Certain buildings may become ‘cold and dark’, or systems drained and depressurised, which may promote plant degradation mechanisms. Plant conditions may also result in restrictions on operations if temperatures fall below limits, so additional heating may be required. Deferred dismantling in particular should consider the longer term ageing and obsolescence programmes associated with SSCs which are not

removed. This may include a proportionate periodic safety review of the plant and safety documentation.

- An understanding of what dismantling activities are permitted during transition. There may be opportunities to carry out limited dismantling activities during the transition period, especially on redundant plant that is remote from SSCs important to safety. It is likely, however, that there will be regulatory or licensing implications associated with these activities. Some countries place an embargo on any such activities. In other countries discussions can be undertaken to define dismantling activities that could be anticipated under the operational licence and carried out during the post-operational phase.

Characterisation

Characterisation provides the understanding of the state of the facility, which is essential for decontamination, deconstruction and waste management activities. It may be beneficial if site surveys and engagement with experienced site staff are carried out at an early stage. Identification of, and an execution plan for relevant characterisation measurements that cannot be performed during operation may be devised in advance of end of electricity production if this date is known. Characterisation should not only focus on radiological hazards, but also consider non-radiological ones such as asbestos, chemicals (e.g. boron) and gases (e.g. nitrogen).

There is comprehensive guidance available on Characterisation in the documents referenced in Annex 1 and other sources.

Waste Management & Hazard Removal

The development of an overall waste management strategy may be one of the first critical tasks in the strategic planning. Using a waste led decommissioning approach is one method used by some countries, and sets the scene for the further strategic and overall decommissioning planning. The strategy is informed by the available routes for handling wastes. As such, ideally this should take place well ahead (several years) of the planned end of electricity production.

Waste management encompasses both radioactive and non-radioactive materials. When a SSC is retired it is desirable to remove any hazard by de-energising, depressurising or draining down as soon as possible. Putting SSCs into a passive state may generate new LLW and non-radioactive waste inventories. Insulation may be removed during the transition, potentially generating LLW and non-radioactive waste. Asbestos and insulation management is a time consuming and hazardous activity that requires special attention.

There is comprehensive guidance available on waste management in the documents referenced in Annex 1 and other sources.

Decontamination

The transition should be informed by an agreed decontamination strategy. As with other strategies, the decontamination strategy must reduce risks and doses to as low as reasonably practical/achievable (ALARP or ALARA). The strategy should be benefit driven, and determination includes considering the balance of risk (dose), environmental impact, availability of resources/experience, alignment to decommissioning strategy (e.g. enabling access vs remote working), alignment to waste strategy (e.g. reclassification of materials, volume of wastes), time, cost and other factors. In some cases early decontamination will be the favoured approach. In other circumstances, for example where a deferred dismantling strategy has been adopted, there may be benefit in not

performing a full decontamination as decay of the radioactivity over time will lead to lower worker doses when this activity is carried out. The decontamination strategy should state which SSCs can be cleaned and/or decontaminated and when.

There is comprehensive guidance available on decontamination in the documents referenced in Annex 1 and other sources.

From the ENISS members' feedback and other sources the following experiences have been identified. This may help to plan a decommissioning project, although not all the experience given in this report is valid for all decommissiong projects, depending on local context.

- Prepare all the documentation necessary for obtaining the decommissioning licence (e.g. final decommissioning plan, decommissioning safety analysis report, environmental impact assessment report).
- Timely preparation of the safety analysis and documentation can be a challenge, especially if a site reaches end of electricity production earlier than anticipated. Prepare the safety analysis and documentation as early as reasonably practicable, recognising that the authorities require sufficient time to consider and authorise any activities.
- Exactly characterising a nuclear power plant waste and contaminated areas can be a significant task. An evaluation based on estimates and experience at the beginning can be sufficient to determine what waste facilities and arrangements are required.
- Early preparation enables greater access to experienced staff, whose knowledge and experience is really useful for key areas such as the plant management strategy and characterisation.
- It is beneficial to secure in advance specialised services providers according to the foreseen dismantling schedule, especially for very specific packages such as dismantling of reactor pressure vessel internals and the reactor pressure vessel.
- Decommissioning can benefit a lot from technical, governance or organisational innovation. The transition phase may be the right time to identify such potential innovations.
- The preparation and management of outages during the operational phase can be considered a relevant practice and a starting point for the transition and decommissioning. Decommissioning involves many aspects similar to some reparation works.
- Some organisations have developed a specialised Business Unit with a focus on nuclear decommissioning. Responsibilities can include developing strategy and competences for decommissioning, managing the resources and delivering the decommissioning programmes. By developing a separate Business Unit for Nuclear Decommissioning, separate from operations, reduces potential conflicts around prioritisation of resources between decommissioning and operations missions. It also allows a "decommissioning-centred" approach to be developed from the outset, where the focus is on the decommissioning mission and tasks is at the heart of the business.
- However, there is a risk if the decommissioning business unit becomes "too separate", since there is a link between operation and decommissioning to take the operational experience, know-how, tacit information etc. into account in decommissioning; and vice versa, in some decisions in operation the effects on the decommissioning should be taken into account.

- Nonetheless there are still challenges in moving from an operations to decommissioning mindset. In particular with respect to specific issues which interface, i.e. where the two organisations have shared but differentiated responsibilities. This requires a structured arrangement under which the interactions and decision-making is managed; as well as development of effective co-operation between the key staff, departments or companies involved.
- Effective organisational change is one of the most significant challenges. Without this in place there could be a tendency to stay operationally focussed above all other priorities, which could lead to lack of clear ownership, plans and accountability for decommissioning activities.
- Starting preparatory activities too late can lead to not being able to anticipate certain dismantling operations under the operating licence during the transition phase, or not being able to implement modifications to installations in order to ease future dismantling operations.
- Having to conduct unnecessary surveillance and maintenance programmes may prevent re-assignment of staff to transition and dismantling tasks.

Principle 3: The licensee engages early to develop an outcome focussed environment with key stakeholders including the regulator, in order to achieve a reasonably practicable and proportionate risk informed transition strategy.

A positive licensee to regulator relationship that covers all relevant regulators, i.e. nuclear safety, environmental, safeguards, security, transport, waste management, worker safety, etc. will be beneficial. An open dialogue with key stakeholders and regulators is beneficial at an early stage, in order to develop a shared understanding of the transition strategy, the required activities and the regulatory expectations. The licensee and regulatory strategies should take a proportionate and holistic approach based on the changing risk profile at the site.

It is important that the legal and regulatory requirements are understood and embedded in the transition strategy. The timescales for regulatory assessment and authorisation should be understood and incorporated into the transition plan. Any failure to satisfy regulatory requirements can lead to significant delays to subsequent steps or other regulatory action.

The nuclear safety risk and radiological hazard will reduce significantly following shutdown and removal of fuel from site, or removal of fuel to a dedicated interim spent fuel storage facility. Other hazards, for example industrial, environmental and radiological protection may increase during some phases as decommissioning activities commence. A proportionate and holistic approach based on the changing risk profile at the site could be helpful. There may be less need for the level of nuclear safety regulation to be maintained, as the risk profile moves away from nuclear risk/hazards and towards conventional, environmental and radiological protection ones. Regulatory supervision should take into account the specific hazards relating to decommissioning, and the key areas relating to supervision of these activities. This may be reflected in a shift in the regulatory emphasis, and will also lead to cultural change, discussed later under Principle 4.

Good governance and oversight of a wide range of areas is advisable in order to maintain this proportionate approach, particularly when facing the evolution for the first time. It is essential to understand the broader operating experience, regulatory expectations and relevant national and international standards.

From the ENISS members' feedback and other sources the following experiences have been identified. This may help to plan a decommissioning project, although not all the experience given in this report is valid for all decommissiong projects, depending on local context.

- An example is to work with the regulator(s) and agree a regulatory strategy and plan to support the transition from operations to decommissioning. This can potentially cover planned and unplanned closures. Capturing the strategy and plan in an agreed document will provide clarity of the regulatory expectations, the licensing hold points and the level of authorisation required at each hold point. It can also set down the framework of regulatory interventions and assessment work, covering a wide range of areas and interactions.
- Another example is where a guide related to "final shutdown, decommissioning and delicensing of Basic Nuclear Installations" is produced (and issued by the Nuclear Safety Authority) and to have discussions with the authorities prior to the submission of the decommissioning application in order to present and discuss the chosen decommissioning strategy (breakdown of the decommissioning process, final state envisaged, etc.).

- It is advisable, if necessary, to clarify the roles of all regulatory authorities involved in authorisation of decommissioning, and harmonising regulatory requirements and criteria between them.
- A goal-setting regime rather than a more prescriptive, standards-based regime is applied in a number of countries (although this is not an absolute, and both approaches can be used depending on the specific issue). With this approach the regulator sets out its regulatory requirements, and it is for licensees to determine and justify how best to achieve them. This approach encourages innovation, continuous improvement and the adoption of relevant good practices and also enables innovation by the operator/licensee to develop approaches that best meet its particular circumstances.
- It is good practice when the nuclear regulator applies a graded approach, and adapts regulatory control to the new post-closure situation (in particular once fuel is removed), and takes account of the new lower risk levels in the transition to the decommissioning phase. It should be noted that this does not imply an overall reduction in regulatory supervision, but rather a change in character or focus, towards a shift into supervision of decommissioning. There may be a build-up in regulatory supervision relating specifically to decommissioning in the period before permanent closure, in relation to the planned changes to the safety analysis for the transition period and/or decommissioning. Regulatory supervision takes into account the specific hazards relating to decommissioning, and the key areas relating to supervision of these activities.
- The applicant for a decommissioning authorisation demonstrates in the documentation that the risk profile and the nature of the hazard have changed in the decommissioning process (and in the transition period as well). The creation of a checklist with hazards and the processing of safety analyses may make it easier in certain cases.
- The nuclear safety risk and consequential regulation differ for each phase of the fuel removal from site, e.g.:
  - spent fuel in permanently shut down reactor;
  - spent fuel removed from reactor, remains in spent fuel storage pool in reactor building;
  - spent fuel removed from reactor building, remains in interim spent fuel storage pools in a separate facility on site (if planned);
  - spent fuel removed from reactor building, remains in interim dry spent fuel storage on site (if planned); and,
  - all spent fuel removed from site.
- The mindset (both of the operators and the authority) in the facilities in operation may not support the graded-approach. In addition to organisational changes of the operator, changes may be necessary also in the authority (e.g. competence and resources relevant for decommissioning).
- Preparation of the requested documentation in a timely manner can often be challenging. During the preparation of this documentation, it is advisable to have interactive communication with the regulator at early stage. Regular discussions or working groups may facilitate this, allowing the identification of any issues upfront in order to ease the final analysis of the submittal and avoid delays in getting the license.
- Such discussions can help define dismantling activities that could be anticipated under the operational licence and carried out during the post-operational phase, for instance in non-controlled areas of the installations, with as main examples the dismantling of equipment of the turbine hall or buildings with already removed steam generators and reactor pressure vessel cover heads, which

would be beneficial to potentially reconfigure those buildings as interim storage locations.

- In some countries where the lifecycle of the licence is established and the necessary licenses are valid, a change of ownership should not be a reason for relicensing (the conditions of activity are set out in the licence). The responsibility is always on the holder of the permit for the activities in question.

Principle 4: Sufficient focus is given to the management of organisational change ahead of and during the transition period.

Organisational change is a major focus area during the transition. There are significant organisational changes and challenges associated with the transition from operations to decommissioning, covering a broad range of areas from the company structure and licensing, changes to the management systems, provision of suitably qualified and experienced personnel, to the culture and morale during a period of great change. It is advisable that preparations begin early to allow optimum organisational change and risk management. Stakeholders and regulators may also undergo similar transitions.

Organisational change is a key enabler to deliver the requirements of decommissioning (and other missions), and is often a rate determining step which determines how well prepared we are for the transition. Hence, slow or delayed organisational change is potentially one of the main inhibitors.

People, plant, process and the commercial aspects of the business have to adapt to manage nuclear power plants which have stopped generating and are commencing decommissioning. There are key skills and knowledge that have to be managed throughout this transition. Additionally there are different skills that have to be developed in order to meet new missions. New business functions, with clear objectives, ownership and accountability may also be required. Taking into account the roles and competences for decommissioning, this may create a requirement to define and deploy a new approach to managing human resources and training.

With the approach of the permanent shutdown of a nuclear facility, detailed preparations begin for the facility transformation required in order to establish the necessary conditions for the start of decommissioning. In particular this transition involves:

- a transformation process to create an organisation suitable for undertaking decommissioning; and,
- actions related to specific phases of decommissioning including undertaking post-operation activities and preparing for the start of decommissioning activities.

The approach to be followed to undertake decommissioning will typically be described in the decommissioning plan, which is maintained and updated throughout the lifetime of the facility. Irrespective of the choice made, this will involve a process of transformation to establish the new organisation required for decommissioning. At the heart of any such transformation will be change management.

Change management is the term given to a process, techniques and tools required to manage the people element of change to achieve the required business outcome. Change is an ongoing process in all organisations, but it is particularly important in nuclear facilities to have a ‘tried and trusted’ methodology to ensure change is implemented effectively whilst remaining focused on safe reliable operation and nuclear safety risks are managed and controlled during the process. In some countries the regulator will insist organisations have adequate arrangements to control any change to its organisational structure or resources which may affect nuclear safety. This may include ensuring that there is robust and visible consideration of different options (optioneering) covering all aspects, technical, safety, regulation, HR management…, in identifying and implementing an effective, reasonably practicable and proportionate solution.

The key aspects of organisational change during transition are summarised below, with further detail provided in the guidance listed under Annex 1 and other sources.

Governance & Oversight

As noted in Principle 1, it is beneficial when the strategic direction is driven from the top-level management of the licensee. Appropriate governance and oversight arrangements will manage all transition activities and the organisational change. Senior management and other leaders should have the right competence in order to carry out this role. This is important in order to manage safety, compliance, programme performance and innovation. In addition to the governance and oversight of transition activities discussed under Principle 1, the following organisational activities also require appropriate levels of governance and oversight:

- leadership and culture;
- governance and organisational innovation;
- changes in operational and decommissioning resource levels;
- skills and knowledge management;
- training;
- management systems;
- organisational structure and ownership (including transfer of responsibilities); and,
- funding.

Key performance indicators/metrics and risk logs are useful tools to help define and measure both performance and organisational effectiveness to enable the prompt identification of any issues or risks that may require mitigation.

Leadership & Safety Culture

During operation, nuclear power plants understandably maintain the leadership & safety culture of a nuclear production facility or factory. The main priority is to safely and securely maintain the production of electricity to meet the demands from the grid. During this period, the main time an increased project focus is applied to the management of the site is during planned outages. As a site nears the end of electricity production, it may benefit from the development of a new mind-set, that of a project organisation. Plans will be made for the defueling and decommissioning of the site, and the organisation may need to adapt itself to provide the structure to deliver these later stages in its lifecycle.

The changes introduced by the end of electricity production and the transition to decommissioning increase the risk of a deterioration in the safety culture unless this is carefully managed. There are some culture changes that should be encouraged, recognising the change in risk profile and emphasis on project working. So an approach proportionate to the risks and type of organisation could be fostered. There are other changes that will be triggered by the change in site mission and the decrease in operational staff levels, which can have an adverse impact on morale and culture. In a period of significant change, consultation, communication and certainty are key enablers to managing culture and morale.

Managing Changes in Resource Levels

As operational functions staffing levels decrease and decommissioning functions increase, appropriate change management arrangements should be in place to ensure that the functions can continue to perform their duties, maintaining safety and compliance, whilst also delivering commercial objectives. These changes are managed to ensure that they remain consistent with the site safety documentation and the transition and decommissioning strategies. Changes should be documented and should be subjected to ongoing monitoring, governance and oversight. It is advisable to engage key

stakeholders early, especially relevant regulators in order to understand their areas of interest for assessment and authorisation.

The dual mission of an organisation, supporting both operating nuclear power plants, whilst preparing for the transition to decommissioning, is a challenge to manage. This challenge may be increased if there are multiple sites that are transitioning at the same time. This will impact both the nuclear power plant and support organisations. As the nuclear power plant nears the end of electricity production, the demands of operation can also increase due to plant ageing. Therefore, prioritisation of shared resources can become problematic, when the over-riding focus is safe operation of the nuclear power plant. It is important during this phase that the organisation finds efficiencies in the work that it carries out to create headroom. Separate dedicated functions may be put in place to protect preparation activities. Various aspects of the transition and decommissioning strategies may be subcontracted to specialist companies, which will help alleviate temporary pressure points.

In order to manage the impact on morale and culture, efforts supporting staff reconversion or other resourcing strategies should commence as soon as possible. This may require dedicated human resources, training and communication resources. Industry partners may also be engaged to help the transition.

Skills & Knowledge Management

Maintaining the right skills and knowledge is an important part of transition. This is in-part identifying and transferring existing skills and knowledge from the operating organisation, and also identifying new skills and knowledge to support decommissioning. Knowledge management is supported by accurate and up to date plant documentation and records, and informed by additional activities such as characterisation. Appropriate Product Lifecycle Management tools should be used. Access to experienced operational staff, original equipment manufacturers and supply chain may identify further relevant knowledge that is not captured within plant documentation and records. Key plant, projects and processes should be covered. Specialised services and additional supply chain support for transition and decommissioning activities should be secured in advance.

During the lifetime of a site, decisions are made as to whether certain tasks are within the core activities of the operator (e.g. for safety, regulatory or commercial reasons). Those that are judged to fall within the core activities will, in most cases, be performed by the site itself - these are classified as ‘make’ decisions. However, as the site transitions from operations to defueling and decommissioning, less of these activities will be judged to be core, and there may be an increased spend in the supply chain (‘buy’). The sites therefore should have a structured process for ‘make’/’buy’ decisions, which includes maintenance of the right skills and knowledge.

Offering training possibilities to existing staff to get acquainted with the decommissioning world and acquire new skills, which are by nature different from the operational ones, can be attractive for some employees. This is to be put in balance with the global decommissioning approach where making use of specialised external contractors can be considered as being more cost effective. This means cost principles will play a role in determining which internal workforce shall be kept and reconverted to decommissioning and if some activities will be internalised or not.

Training

A training process, such as the Systematic Approach to Training (SAT) or equivalent, is a relevant example of a process that manages adjustments to existing competences and new competences. Such a process will analyse the skills, knowledge and behaviours required for transition and beyond, and then use a structured approach to design, develop, implement and evaluate training packages.

The training requirements should take a long term, strategic view, as recruitment, training and development can be long lead time activities. Collaboration across the industry and with key strategic contractors should be considered.

Management Systems

The management system of an organisation describes how key activities are managed, performed and assessed. It typically shows how the organisation is governed and describes how functional responsibilities, levels of authority and interfaces between different groups are controlled and managed such that the overall objectives are achieved in a safe, efficient and effective manner. It typically defines how the management system integrates safety, health, environmental, security, quality and economic objectives to ensure that safety is not compromised. It may also be part of the arrangements used to demonstrate compliance with the Site Licence.

The management system may also control activities through transition and into decommissioning. It should be reviewed ahead of transition to identify areas that require adjustment to the new mission. Work control processes may require adjustment, adapting from routine operational activities, some of which may be maintained, some may become redundant or there may be new one off or novel tasks. The organisation may need additional support to manage the volume of change through the transition period.

The management system may also be supplemented by additional QA plans and internal regulatory assurance during the transition.

Organisational Structure & Ownership

The ownership and/or licence holder may undergo change during or after the transition. A number of options have been chosen by different countries:

- the organisation that held the licence during operation may continue to hold the licence through transition and decommissioning and deliver the transition and decommissioning activities;
- the organisation may choose to enact decommissioning by a specialist contractor under the oversight of the original operating organisation, which continues to hold the site licence; or,
- the ownership and site licence may transfer to a new organisation after defueling.

The option chosen will depend on factors specific to the organisation and country.

In all cases there will be organisational change, with overlap and potential conflicting priorities between operating and decommissioning functions. The organisational capability, competence and knowledge of both the operating and decommissioning functions will be managed. The operating functions must maintain sufficient capability as the number of operating staff reduces. It is preferable that the decommissioning functions have sufficient capability at an early stage in order to support the Principles identified in this paper, and be able to increase resources in order to implement the transition and decommissioning strategies. Key resources, skills and knowledge are identified and maintained throughout. Additional contract resource may be required to manage periods of peak resource demand.

The transfer of ownership, the site licence and any permit/authorisations should be managed to enable a seamless transfer. This will require early engagement with the regulators and collaborative working between the licence holder and new licensee.

Funding

Funding is a key enabler, or potential inhibitor, to the development and execution of the transition strategy. Each country will have different arrangements for the accumulation and provision of decommissioning funds. The availability of funds may impact decommissioning activities and the decisions taken on priorities and approaches. Organisational change may be required to work within an environment where funding for decommissioning work requires additional qualification and use of funds requires additional oversight, in order to avoid any delays to the programme. There may also be regulatory interest in the provision of sufficient funds to implement the agreed strategy.

Where there is a change in ownership, it is essential that the correct commercial framework is in place to control that transition. There may need to be a restructuring of the site's workforce to reflect the new focus of the site, but continuity should also be considered to ensure that appropriate site knowledge is preserved and licence conditions are complied with. The correct commercial framework should help to prevent the operator from leaving the new owner with insufficient or inappropriate resource to carry out the decommissioning.

From the ENISS members' feedback and other sources the following experiences have been identified. This may help to plan a decommissioning project, although not all the experience given in this report is valid for all decommissiong projects, depending on local context.

- Slow or delayed organisational change, or competing priorities between operating sites and sites transitioning to decommissioning, can result in significant delays. It is preferable that the organisation can adapt to the new mission and tasks. The challenges during operation differ from the challenges during decommissioning. It is important to refocus the organisation to the new mission. This may require creation of new functions and separate, dedicated and protected resources. It may also require adoption of a more project focussed delivery organisation. Make sure that roles and responsibilities are clear and that there is an efficient decision-making process in place, especially if responsibilities are split between two, or more, organisations.
- The transition period and subsequent decommissioning can be associated with a major reduction in operating staff. It is of vital importance to keep the operational knowledge of the operators during the post-operational (transition) phase, and even beyond into the decommissioning phase. Therefore, keeping critical operational staff on-board is an important task and has to be managed by providing them with career perspectives, or possibly by putting in place a system of incentives. This system has to take into account the age of the concerned employees, mainly by assessing for the senior ones if they can reach the end of their career by working on the decommissioning project or for junior ones by offering the possibility to still work for the company but on other sites/installations, if any.
- Culture and morale can be challenged during a period of significant change. There are a number of practices for maintaining culture and morale, including:
  - begin early by initiating a change in the mindset: production to decommissioning;
  - open and honest communication about the employment horizon of staff;

  - strong involvement of staff in designing their training path when transitioning into decommissioning work;
  - company support for staff in planning their careers after decommissioning;
  - provide staff with opportunities to acquire certificates to help future employment;
  - open and early communication to the community, local authorities and the media about the project and how it is a normal procedure at the end of a plants electricity production;
  - close co-operation between the local community/stakeholders and the licence holder will lead to a more sustainable outcome as the necessary organisational changes take place. The effect of these changes on the local economy can be minimised with a common effort that is initiated early;
  - key staff can be motivated to continue in the project with different forms of incentives;
  - staff involvement in the planning phase increases commitment later;
  - developing training courses about radioactive waste management and decommissioning activities so that operating staff get acquainted with this rather new business area for most of them;
  - preparing a reconversion programme for the operating staff, encompassing retirement, reorientation to other activities within the company, outsourcing and a training programme for the staff that will shift from operation to decommissioning;
  - increased training of managers and especially their leadership skills, with a focus on the requirements of transition and decommissioning, will increase both their success as leaders and also their own motivation, since the company is clearly investing in them; and,
  - line managers should be committed and see the changing projects as an opportunity for growth, so they can pass this attitude on to the staff.
- Operational staff with knowledge of the environment and equipment are further usable in the decommissioning process, they only change their role and become the guarantor of decommissioning activities - not their executor. Existing operating staff perform dosimetric inspections, formulate assignments for suppliers, use their knowledge in entering technical specifications, etc., this knowledge and experience can be used in the decommissioning of a nuclear power plant. On the other hand, the decommissioning process is linked to other activities for which the operating staff are not trained and which they may not want to perform. Therefore a staffing program for employees and their future career prospects / perspectives should be established.
- When transferring staff from the operating organisation into the decommissioning organisation, an effective on-boarding programme and mentoring should help establish a decommissioning mindset. It should be noted that the decommissioning organisation also stands to gain through transfer of staff from the operating organisation, in that this facilitates developing an awareness of the needs and approaches of the operating organisation, which should facilitate the interactions between the two.
- The decommissioning organisation has to establish new relationships with the commercial supply chain for nuclear decommissioning. These differ in some key respects from the commercial frameworks applicable for operations, both in terms of supply chain partners and also in choice of contracting models and relationships. There may be different funding and financing arrangements for waste disposal (including spent fuel) and decommissioning.

- Hiring new categories of staff (or reinforce them) to better be able to put transition and dismantling contracts in place and ensure the necessary follow-up of the dismantling contractors (cost and schedule controlling).

3. Conclusions

The experiences of the ENISS members have been collated and reviewed and presented in this paper. The focus of this paper is on licensing and organisational change. To communicate the common position, principles have been developed which cover:

- **Principle 1: Strategic direction is provided by the licensee in order to prepare for the decommissioning of a nuclear facility.**

- **Principle 2: Active preparation activities commence sufficiently ahead of the anticipated end of electricity production.**

- **Principle 3: The licensee engages early to develop an outcome focussed environment with key stakeholders including the regulator, in order to achieve a reasonably practicable and proportionate risk informed transition strategy.**

- **Principle 4: Sufficient focus is given to the management of organisational change ahead of and during the transition period.**

Annex 1: Other reference material.

The following documents may help to plan a decommissioning project. Although not all the advice given in these reports are valid for all decommissiong projects. Therefore the ENISS members have to decide for their own, whether they use these documents or not.

There are a wide range of national and international standards and guidance available covering different aspects of the transition from operations to decommissioning. The following section summarises key international sources focussed on the transition from operations to decommissioning. Experience from other decommissioning projects, best practices and lessons learnt will also provide valuable operating experience.

IAEA Safety Report Series No.36 'Safety Considerations in the Transition from Operation to Decommissioning of Nuclear Facilities', 2004

The objective of this Safety Report is to provide information to help in ensuring safe management of the transition from the operational phase to the beginning of implementation of the decommissioning strategy for nuclear facilities. The goal during the transition period is to achieve a significant reduction in radiological hazards through the safe termination of operational activities and removal of radioactive material, and to place the facility in a stable and safe condition until the decommissioning strategy is implemented. During this period, control of any remaining spent fuel, other radioactive material or nonradioactive hazardous material should be maintained, and the safety of the workers and the public, and protection of the environment, should be ensured.

This Safety Report supports the recommendations and guidance provided in three IAEA Safety Guides that address decommissioning of nuclear installations [5–7 below]. The emphasis is on the safety issues involved in the main operations and activities needed in the transition from the operational phase to the implementation of the decommissioning strategy when considering and planning for permanent shutdown.

The content covers the organisational, strategic and administrative activities to be performed during the transition period, including:-

- Changes to the operator's organisational structure, preparation of the final decommissioning plan, the decommissioning safety analysis report and an environmental impact assessment in order to get a decommissioning license.
- Licensing during the transition period. Depending upon the requirements of the regulatory body, transitional operations may be undertaken under the operating licence, a specific licence, an overall decommissioning licence, or under direct control by the regulatory body.
- The operations to be undertaken during the transition period. For each operation, specific safety concerns are identified and mitigating actions suggested. Lessons learned from operations in facilities and plants that underwent transition periods in the past are also included. Areas include: administrative and plant controls; social and economic aspects; fuel handling; drainage of systems; cleaning and decontamination; estimates of the physical and radiological inventories of radioactive materials; treatment & conditioning and removal of operational waste; retirement, reconfiguration and planning for the provision of new systems; changes to confinement barriers; and accidents and incidents that are possible during the transition period.

Organisational, strategic and administrative activities and the technologies associated with the transition period are addressed in more detail in a companion IAEA Technical Report (Technical Report No.420, summarised below).

IAEA Technical Report No.420 'Transition from Operation to Decommissioning of Nuclear Installations', 2004

The objective of this report is to provide practical advice and information on important aspects of the operation to decommissioning transition with a view to minimising decommissioning delays and avoiding unnecessary costs during final planning for decommissioning.

The focus is on preparatory activities for implementation of a decommissioning strategy. In particular, this report aims to ensure that the transition between operation and implementation of the decommissioning strategy is managed safely, effectively and efficiently. It addresses strategic issues such as planning, administration and implementation. Safety aspects associated with the transition period such as changes to regulations, safety systems or accident analysis, as well as licensing of the transition period, are dealt with in the previous IAEA reference (Safety Report Series No.36).

The main part of this publication describes key aspects of the transition period. It emphasises three topics:-

- The overall approach and organisational and structural issues.
- Practical issues relating to planning, management and administration.
- Technical issues relating to implementation of the transition, including the costs.

Annexes describe the approaches to and the experience of the transition period in various countries and case studies of problems encountered, solutions and lessons learned during the transition period.

Nuclear Energy Agency (NEA) No. 7374 'Preparing for Decommissioning During Operation and After Final Shutdown', OECD 2018

The NEA report provides observations and recommendations relating to the development and optimisation of decommissioning strategies, as well as plans to prepare for the decommissioning of nuclear facilities. Rather than providing detailed descriptions of the relevant methods or technologies, the report focuses on strategic approaches, different issues that might arise, risks and observations of NEA members experiences.

The report draws on experience of NEA member countries in preparing for decommissioning and dismantling so as to identify considerations to be made, decisions to be taken and activities to be carried out, as well as interrelations between certain aspects and key issues so as to prepare and plan for the decommissioning of a nuclear facility. It summarises observations, examples and recommendations relating to the development and optimisation of planning for the decommissioning of a nuclear facility. The observations and findings presented in this report are based on the experiences of NEA member countries, as well as on a review of international publications.

The content includes:-

- The constraints/key enablers and strategic decisions that lead to and set the course for decommissioning planning, which forms the basis for preparatory activities.
- Detailed information on aspects that have been identified as key factors enabling the effective and efficient conduct of a decommissioning project with timely preparation and planning, including:
    - pre-dismantling and post-operation activities;
    - regulatory framework and authorisation for decommissioning;
    - external stakeholders; and,
    - organisation transition.
- Annexes present:

- case studies from different NEA member countries to illustrate aspects related to the preparation of decommissioning and transition;
- the more common contracting models for the supply chain;
- a comparative summary of different requirements for decommissioning, preparatory activities and responsibilities in various NEA member countries;
- further information on the training programmes of nuclear facilities that are based on a systematic approach to training (SAT); and,
- a comprehensive bibliography of international standards and guidance, as well as national documents related to the transition from operation to decommissioning.

Other relevant standards and guidance applicable to decommissioning, but not specifically focussed on transition, include:

1. The Principles of Radioactive Waste Management, Safety Series No. 111-F, IAEA, Vienna (1995).
2. Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, Safety Standards Series No. GS-R-1, IAEA, Vienna (2000).
3. Safety of Nuclear Power Plants: Operation, Safety Standards Series No. NS-R-2, IAEA, Vienna (2000).
4. Predisposal Management of Radioactive Waste, Including Decommissioning, Safety Standards Series No. WS-R-2, IAEA, Vienna (2000).
5. Decommissioning of Nuclear Power Plants and Research Reactors, Safety Standards Series No. WS-G-2.1, IAEA, Vienna (1999).
6. Decommissioning of Medical, Industrial and Research Facilities, Safety Standards Series No. WS-G-2.2, IAEA, Vienna (1999).
7. Decommissioning of Nuclear Fuel Cycle Facilities, Safety Standards Series No. WS-G-2.4, IAEA, Vienna (2001).
8. Safe Enclosure of Nuclear Facilities during Deferred Dismantling, Safety Reports Series No. 26, IAEA, Vienna (2002).
9. Radiological Characterization of Shut Down Nuclear Reactors for Decommissioning Purposes, Technical Reports Series No. 389, IAEA, Vienna (1998).
10. Managing the Early Termination of Operation of Nuclear Power Plants, IAEA Safety Report Series No.31, 2003
11. Managing the Unexpected in Decommissioning, IAEA Nuclear Energy Series No. NW-T-2.8, 2016
12. Decommissioning of Facilities, Safety Standards GSR Part 6, IAEA (2014)
13. R&D and Innovation Needs for Decommissioning Nuclear Facilities, NEA No 7191 (2014)