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DECOMMISSIONING THE NEED FOR A HOLISTIC APPROACH

- Strategy and Regulation
- Safety and Organisation
- Dismantling and Waste Management
- Public Acceptance and Information
- Funding Decommissioning

TO OUR READERS

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Jacques Repussard and Lothar Hahn

Not leaving to future generations the burden from today's way of life is one basic principle of sustainable development.
This is to be heard so commonly that it may sound mostly fashionable. But at a time where numerous first-generation nuclear plants are brought to a final stop, dealing with the life-cycle back end of such facilities becomes an utmost meaningful issue to society. Thus, if the decommissioning challenge is to be met timely, a shift from an experimental to an industrial activity must be successfully performed.
This is why it was decided to devote the present issue of the EUROSAFE Tribune to decommissioning, a term applied to the activities leading to the release of a nuclear facility, other than a disposal facility, from regulatory control. Beyond this administrative term, quite different strategies range from the eventual reuse of the site for further nuclear activities to the way back to a greenfield state.
Beyond this term, a complex reality exists that encompasses also the various facets of decommissioning: strategy, regulatory aspects, radiation protection and safety, organisation and human factors, dismantling techniques and tools, research needs, spent fuel and waste management, public acceptance and information, and - last but not least - funding. Drawing upon the experience gained in various European countries, the present issue of the EUROSAFE Tribune aims at providing material for assessing the requirements and relevant strategies to be applied locally. Moreover, it clearly shows the need for a holistic approach. ●

NUCLEAR FACILITY DISMANTLING: A SAFETY AUTHORITY'S VIEW

André-Claude Lacoste,
Director, Autorité de Sureté nucléaire (ASN)

To date, the French experience in dismantling is limited to relatively small facilities such as laboratories or research reactors. The first "industrial-scale" dismantling operations, linked to the decommissioning of EDF's Nuclear Power Plants, are about to be performed. The French power company's initial policy in this domain was to get the nuclear material removed, to carry out the very first steps of dismantling and to wait for several decades for the natural decrease in radioactivity.

EDF's policy change

▼ ASN, the French nuclear safety authority, pushed for a change in EDF's policy for several reasons: firstly, no radioactive decrease with substantial effect on the doses involved in dismantling operations is to be expected, even after a long period of time; secondly, the risk that financial provisions devoted to dismantling may be reallocated increases with time; thirdly, dismantling tasks require in-depth knowledge of the facilities whereas this pool of expertise depletes as operating staff members retire; fourthly, early dismantling does not generate any overwhelming challenge from a technical perspective.

▼ The dismantling of the small-size power reactor located in Brennilis, Brittany, is a good example of this policy change. The French power company was imposed by decree to undertake a comparative study between immediate dismantling and deferred dismantling. The results showed that the benefit associated with the safe enclosure option or deferred dismantling, was fairly limited or even written off by the progressive loss in operating knowledge. This brought EDF to revise its policy, backed by the 2003 regulatory circular which requires a consistent approach to dismantling up to completion.

Dismantling and waste management: an integrated process

▼ In this respect, a relevant dismantling project should include a waste management strategy. This is why ASN urges waste management facilities to be opened at the appropriate time. This is already the case for Soulaines, the short-lived, low- and intermediate-level waste repository, as well as for Morvilliers, the very-low-level waste repository.

▼ A facility devoted to graphite waste disposal still has to be designed. This calls for a national waste management programme to be

A FEW CONSIDERATIONS ON...

...the importance of knowledge conservation

The Brennilis experience, and other experiences involving laboratories, show how crucial an issue memory is. With the dismantling programme accumulating delays, it became impossible to identify with sufficient certainty which fluids were flowing in which pipes. CEA had to rely upon the memory of its retired staff for recreating the reactor's operating life and checking if certain incidents might have caused pollution.

...getting the operator's buy-in for immediate dismantling

The present generation is becoming increasingly aware of the necessity of dealing with the liabilities resulting from industrial activities: waste management, facility dismantling, site remediation, etc. It is no longer accepted that such liabilities be left as a financial and technical burden to future generations. This pressure from society thus helps regulators persuade operators to work on immediate dismantling and waste management projects.

...bringing dismantling and waste management policies together

As a member of WENRA, the Western European Nuclear Regulators Association, ASN works in close relationship with its counterparts in many countries. Among other exchanges, those pertaining to dismantling and waste management issues illustrate the difficulty of achieving alignment, since views largely result from differing national contexts and cultures. The French policy, for instance, clearly gives preference to surface and subsurface waste repositories, whereas the Germans are in favour of deep storage. Moreover, one condition commonly set for approving the construction of waste management facilities is their restriction to only handling nationally generated waste. This provision obviously does not contribute to facilitating alignment.

established so as to define a specific management strategy for each type of waste. This interaction between dismantling and waste management might partly explain how the obstacles in the development of a deep repository in the Sellafield region influenced the UK policy in favour of the deferred option.

▼ It also should be noted that dismantling does not automatically lead back to a greenfield, since release of the site for uncontrolled use is an extremely demanding option from a technical as well as economic perspective. A smart use of the site, therefore, might be to "recycle" it for another technical purpose, for example as the Japanese used to do, since the best way to keep the site under surveillance undoubtedly is to maintain an operator. In this respect, the prerequisite to future use of the facility is a clear distinction by the operator of the zones free of industry-generated radioactivity and those impacted.

▼ Drawing upon the knowledge gained on the FBFC fuel fabrication plant at Pierrelatte, EDF is presently embarking on a wide-scale dismantling programme of several reactors - Superphénix, Brennilis, Chooz, Bugey 1, Chinon and St-Laurent - and setting up an ad hoc structure - CIDEN - to provide the necessary means to do this. ●

Dismantling of spent-fuel storage facility.

DECOMMISSIONING STRATEGIES:
DIFFERENT WAYS BACK TO A GREENFIELD

By Gordon Linsley, Dennis Reisenweaver and Luis Jova Sed, International Agency for Atomic Energy (IAEA), Division of Radiation and Waste Safety, Waste Safety Section

The ultimate aim of decommissioning is to allow for the removal of some or all regulatory controls of the site. Decommissioning is increasingly becoming a major issue, since tens of nuclear power plants (NPPs) will end their operational life during the next 50 years. Three basic decommissioning strategies are envisaged as possibilities for these nuclear installations: immediate dismantling; safe enclosure prior to deferred dismantling; and entombment. However, each situation has to be examined individually to identify the optimal strategy for that situation.

While there is considerable regulatory experience at the "front end" of the regulatory system for the design, construction, commissioning and operation of NPPs, the experience at the "back end" is, at present, limited, since comparatively few installations have actually been decommissioned. Nevertheless, a recognisable international strategy for decommissioning is emerging. It can be seen in the relevant Safety Standards of the IAEA, which have been developed and approved by committees of national regulators, and most recently in the findings of the International Conference on Safe Decommissioning for Nuclear Activities, held in Berlin, Germany, in October 2002.

Storage of radioactive waste from dismantling.

› **Immediate dismantling.** This term means a decommissioning strategy in which the equipment, structures and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations. It implies prompt and complete decommissioning. It involves the decontamination, dismantling and removal of all equipment, structures and other parts of the facility that had become radioactively contaminated.

Advantages. Immediate dismantling typically has the fewest uncertainties, eliminates the risk associated with the facility promptly, will normally cost less than delaying dismantling and allows the use of operational staff who can contribute their expertise and experience during the decommissioning process. The German experience of decommissioning VVER reactors showed that prompt decommissioning resulted in lower cost, less waste production and lower radiation dose commitment than the other alternatives. It has also demonstrated that the decommissioning of this type of reactor is feasible and not particularly complex.

Constraints. Since immediate dismantling requires waste to be dealt with immediately, the absence of a waste disposal route may be an impediment. However, the Berlin Conference concluded that the absence of a repository should not prevent immediate dismantling. If repositories are not available, regulators should provide guidance to operators on the appropriate arrangements for the safe conditioning and storage of waste.

› Deferred dismantling or safe enclosure. This is a decommissioning strategy in which the nuclear facility is placed and maintained in such a condition that it can be safely mothballed and subsequently decontaminated and/or dismantled to levels that permit its release for unrestricted use. As the name implies, this usually involves placing the facility in a safe, stable and monitored condition, and keeping it in that state until a decision is made to dismantle.

Advantages. Safe enclosure may have benefits for facilities which contain short-lived

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radionuclides that represent an important source of risk. It may provide "breathing space" in cases where sufficient funding is not yet available, or may be convenient where there are multiple facilities on the same site. The absence of an available disposal route also has been used as an argument for choosing the safe enclosure strategy; the idea being that dismantling is delayed until a repository becomes available.

Constraints. The aforementioned benefits should be considered in the context of the additional costs associated with providing long-term surveillance and maintenance, the problem of ensuring that sufficient expertise and knowledge will be available for dismantling, and the additional uncertainties introduced by delay (e.g. financing, changes in regulatory requirements, etc.). The safe enclosure concept implies that the operator would need to operate a surveillance and monitoring programme and have contingency plans in place in the event of unforeseen occurrences or to decommission early, if problems occur. This may be particularly difficult if the operator terminated operation or the national nuclear programme has come to an end.

› Entombment. This is a decommissioning strategy in which radioactive contaminants are encased in a structurally longlife material until the radioactivity decays to a level permitting unrestricted release of the property. As a general principle, entombed facilities should comply with radiological criteria for waste disposal facilities, but more specific international guidance is needed on the long-term safety conditions which should govern the entombment strategy.

Advantages. Entombment eliminates the need for total decontamination by pro- →

➔ ceeding directly from deactivation to the encasing of radioactive contamination in a structurally sound material such as concrete.

Constraints. The entombment structure must be appropriately maintained and continued surveillance must be carried out until the radioactivity decays to a level permitting release of the property.

Entombment may be an option for states needing to decommission a single facility and not having the resources to develop or obtain the infrastructure needed for dismantling and waste disposal.

› The need for early planning for decommissioning. In any project there are associated uncertainties and managing these is an integral part of project management. Whatever option is envisaged, planning for a successful and safe decommissioning project should therefore start early, ideally when the facility is being designed. It should address the establishment of mechanisms for the funding of decommissioning and should anticipate that facilities may cease operations prematurely for technical, economic or political reasons.

› Immediate dismantling: the favoured approach. A strategy that involves intensive care and maintenance far into the future will be subject to more uncertainty than one that does not, and this in itself can be a powerful driver for choosing the immediate decommissioning option. For example, cost estimates would need to contain appropriate risk margins to accommodate these uncertainties.

The presentations and discussions at the Berlin Conference indicated a distinct shift in recent years towards immediate dismantling as a preferred strategy. This preference seems to be based on a range of considerations, notably the availability of know-how and experienced staff from the operational phase, and the certainty of funding. Nevertheless, there will still be cases in which one of the other strategies - safe enclosure or entombment - may be appropriate.

Removal of stored materials.

› Removal of regulatory control: obviously a matter of public concern.

The ultimate aim of decommissioning is to allow the removal of some or all regulatory controls from a site. However, it may not always be practicable to release sites for uncontrolled use (i.e. any use), and controls on the future use of some sites or parts of sites may need to be maintained. There has been extensive international discussion on the radiological criteria appropriate for the release of materials for recycling or reuse. Several countries agree on the use of an individual dose criterion of around 10 μSv/yr as a basis for determining the activity concentrations of artificial radionuclides below which release can be allowed. For naturally occurring radionuclides, criteria based on the worldwide average levels of natural radionuclides in the environment (around 0.5 Bq/g) are being proposed as the level below which release can be permitted.

Radiological criteria for the release of sites and buildings are not yet well established internationally and the Berlin Conference showed that a range of radiological criteria is currently being used in different countries.

The release of materials and sites from regulatory control is a subject which concerns the general public, for obvious reasons. Thus, decision making in this area must take due account of the opinion of those who may be affected. ■

NPPS DECOMMISSIONING:
AN ANTICIPATION-ORIENTED REGULATORY APPROACH

By Tom E. Murley, consultant to the Nuclear Energy Agency (NEA), and Miroslav Hrehor, Nuclear Safety Administrator, Organisation for Economic Co-operation and Development (OECD)/NEA Nuclear Safety Division

Although the public health risks posed by a shutdown facility are substantially reduced from those of an operating facility, the decommissioning period requires special attention from both the operator and the regulator. In this regard, the operator has the primary responsibility that the health and environmental hazards and physical protection measures of the shutdown facility be managed properly during the decommissioning process, while the regulatory body is to independently assure that decommissioning activities are conducted safely, that radioactive materials and spent nuclear fuel are disposed of properly, and that the site is in an acceptable end state.

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› From operation to decommissioning: major challenges to be anticipated.

A change in mindset. The transition from operation to decommissioning represents a special challenge for the operator as the actions taken will be effectively irreversible. The operating staff tend to view a complex nuclear facility in terms of systems that run throughout the plant, whereas decommissioning staff, especially during the dismantlement phase, tend to view the facility in terms of areas that must be taken down. Thus one of the biggest changes will be the change in mindset among the workers of the operating organisation.

A change in public concern. The population living near a nuclear facility may have become accustomed to its normal operation, but they are naturally concerned that a new activity like decommissioning be done safely and they may be even more concerned about plans for the long-term condition of the site.

New challenges for the operator... There are some important policy issues that should be considered well before the facility is shut down and decommissioning begins. For example, planning for radioactive waste and other waste management and disposal should be done well in advance of shutdown. A strategic plan prepared while the plant is still operating should be accompanied by more specific plans and safety analysis of the tasks to be undertaken immediately after shutdown.

...as well as for the regulator. The regulator will want to have some early assurance that the decommissioning strategy will result in an acceptable final end state and that there are adequate resources to accomplish it safely. Regarding its own organisation and procedures, the regulatory body will naturally have to review ➔

→ and revise its oversight plans for the facility to focus more on the new organisational, human factors and dismantlement issues, and it may need to augment staff expertise in those areas.

› Organisation and human factors: retaining staff competency and maintaining the safety focus. The facility management must have plans for retaining adequate staff competency, for maintaining the safety focus of the staff and for sustaining the overall safety culture of the site. It will be important that the operator retains an appropriate mixture of experienced workers with organisational and operational memory, and new workers with decommissioning experience.
The regulator will certainly want to know of the operator's plans for maintaining the safety focus of the staff and for the management of contractors, and will also want to review the specific procedures for facility change control and for maintaining site records. In addition to frequent meetings with site management, the regulator will want to conduct regular inspections in the months after shutdown to look for possible adverse trends in the overall safety culture at the site.

› A major preparatory step: surveying and sorting components and materials. Before substantive decommissioning activities can begin the operator will need regulatory approval, and the operator must confirm that the broad strategic plans are still valid and that adequate financial resources are available for the immediate work ahead. An early activity will be to conduct a comprehensive site survey for radioactive and hazardous material contamination in buildings, in the ground and in groundwater. The

Decontamination of activated concrete parts.

operator will no doubt begin to separate salvageable components and materials for asset recovery, and procedures must be in place for the surveying and release of such materials. Before decontamination is started however, the operator must carefully distinguish systems and components that may be depowered and drained from those which are still needed for ongoing functions such as spent fuel cooling. All of these activities should be reviewed by the regulatory staff. Since this initial period of decommissioning will be a very active time at the site, the regulator may find that its inspection and oversight are more intense than when the facility was operating.

› Radiological and environmental controls: coping with the absence of consensus. The radiological protection and physical safety of workers will be challenged by the decontamination, disassembly and removal of large radioactive components. These activities will require careful planning and adherence to sound ALARA principles. A difficult policy issue for many regulators is that of defining acceptable clearance criteria for the release of waste material from nuclear regulatory control. There is currently no consensus within OECD countries on clearance criteria for the unrestricted release of waste material. Thus specific regulatory guidance will be needed on radiological and environmental controls for decommissioning.

› Safety and security: reduced radiological risks, new challenges. Once a nuclear reactor has ceased operation and the fuel has been removed from the reactor vessel to a safe storage location, the radiological risks to the offsite public are greatly reduced. Nonetheless, the regulator will expect the operator to update the safety analysis report or prepare a specific decommissioning safety report to ensure that all decommissioning risks have been considered and analysed, and that the appropriates measures have been planned. A major challenge for both the operator and regulator will be to decide which regulatory requirements that were in place for the operating facility can be modified for the decommissioning phase. Also, the security plans for the site will have to be revised to protect against diversion of nuclear materials to unauthorised uses and to protect against sabotage during decommissioning. The regulator can expect that each of these modifications to operational regulatory requirements will require review and discussion with operator management.

› Waste management: a potential bottleneck named storage. Special plans and procedures will be needed for removing the large components such as the reactor pressure vessel, steam generators, etc. The reactor vessel presents a special challenge because it is intensely radioactive and may not be permitted to be disposed of in a low-level waste site. A major factor affecting the successful completion of decommissioning a nuclear facility is the availability of a repository for disposing of low-level and intermediate-level radioactive waste. If necessary, new interim waste storage capacity will have to be constructed. The question of waste treatment, storage and disposal requires regulatory guidance. It is important that requirements and responsibilities be defined clearly, particularly in the cases where intermediate storage is built to store waste until a final disposal site is available.

› License termination: establishing a clear set of site release criteria. The final regulatory decision associated with a nuclear facility at the end of decommissioning is the decision to terminate licenses. The end state does not necessarily have to be a "greenfield" condition. Some buildings or facilities may remain on the site, as long as they meet the site release criteria. A portion of the site may remain under a new type of nuclear license for storage of spent fuel in special storage casks. In many countries, a particularly difficult challenge for the regulator is to establish a clear set of site release criteria for terminating the license. There is currently no consensus within OECD countries on a preferred set of site release criteria or even the form of such criteria. The final regulatory oversight activity at a decommissioning site will be to review the plans for the final site survey and the results of the survey. When the regulatory body is satisfied that its site release criteria have been met, it can take actions to terminate all licenses.

› Public policy issues: the benefits of open and didactic communications. Experience has shown that public interest and concern over decommissioning issues can be quite high. Typically the public concerns are centred on safety and radioactive releases during decommissioning, on plans for the long-term condition of the site and the residual risks of the site after all licenses have been terminated. It is important for the operator to have regular public discussions to explain their plans and activities and especially the long-term plans for the site. On its side, the regulatory body should also plan on meeting with the public to present the regulatory perspective on the issues and listen to public concerns. ■

Dismantling of washer and piping.

RADIATION PROTECTION DURING DECOMMISSIONING WORK: A FULLY-FLEDGED APPROACH

By Lutz Ackermann, Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), Henri Drymael, Inspections Coordinator, Association Vinçotte Nuclear (AVN), and Marc Champion, IRSN

Decommissioning operations will represent one of the most important and complex sources of occupational exposure in the future. They are therefore a priority area for applying basic radiological protection principles, particularly the optimisation approach. Even though appropriate actions are often implemented in facilities, nuclear operators experience difficulties demonstrating that radiological protection is being correctly maintained. This requests the setting up of a dedicated framework which takes into account the great diversity of facilities involved. Perspectives from Belgian, German and French safety assessment organisations are given below.

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› In Belgium. Two decommissioning programmes are in progress: the former Eurochemic fuel reprocessing plant and BR3, a small PWR (11 MWe). At present, the majority of the most contaminated or radioactive equipment has been removed and treated as radioactive waste. Materials (concrete, metal) have been released if their radioactivity level is below release criteria. In its role as Authorised Inspection Organisation, AVN is monitoring all activities related to nuclear safety and radiation protection. The Belgian experience did not bring to light any new or especially difficult problems related to radiation protection during decommissioning work.

› In Germany. Currently 17 power and prototype reactors are in various phases of decommissioning (safe enclosure and dismantling) in Germany. Despite the lower potential hazard, the Atomic Energy Act demands the same strict criteria for the decommissioning of nuclear facilities as for their operation. The necessary measures are specified in the decommissioning license or licensing steps respectively.

During the decommissioning activities the requirements of the Radiation Protection Ordinance for the protection of the public, the environment and the decommissioning staff have to be fulfilled, as well as the requirement for the optimisation of the exposure of individuals. The effective dose limits for the occupationally exposed workers and the public in the environment are 20 mSv/year and 1 mSv/year respectively. Furthermore there are special criteria fixed in the Guidelines for the Protection against Radiation of Personnel during the Execution of Maintenance Work in Nuclear Power Stations with Light Water Reactors which is applied also for decommissioning activities. During the decommissioning activities the ALARA principle is realised using feedback routines extensively. The experience gained up to now shows that NPP decommissioning can be performed with quite low radiation exposure to contracted and utility personnel and without hazard to the public in the area concerned.

> In France. The authorities are looking for general rules leading to optimum management of radiological protection, as underlined in the European directive 96/29/Euratom. In order to establish a common language with major nuclear operators in the field of operational radiological protection during decommissioning operations and to try to determine what can be considered as good practice, the Institut de radioprotection et de sûreté nucléaire (IRSN) issued guidelines which precisely define the key requirements and approaches involved for optimising each aspect linked with radiological protection during decommissioning operations (*see table*). ■

Key points	Approach involved
1. Regarding the organisation for radiation protection • the consistency with the organisation for safety and its integration • the independence between the action line and the control function • the management of dedicated means and resources • the interface between the operator's units • the management of subcontractors • the means for checking and inspection • the diagnosis of the organisation with its operation status	• dose predictions • optimisation approach • experience feedback
2. Regarding the radiological inventory and characterisation of sources • the accurate definition of exposure sources and their justification • the description of the physicochemical form of radionuclides • the evaluation of the evolution in time of source term	• dose predictions • optimisation approach • radiological zoning • monitoring devices • experience feedback
3. Regarding the analysis of exposure risk • the inventory of high-risk operations and workplaces • an exhaustive identification of exposure pathways and working conditions	• all the operational radiological protection • optimisation
4. Regarding the definition of operating procedures and dose predictions • the definition and schedule of operating procedures, workplaces or operations according to the life status of the nuclear facilities • for each facility: the existence of dose predictions (external and internal exposure) with calculation hypotheses • the evaluation of radiological stakes	• risk analysis • dose objectives • optimisation approach • monitoring devices • protection actions • experience feedback
5. Regarding the prevention and leading of operations • the description of preventive and organisational dispositions, such as: - the elimination of some radioactive sources - the reduction of exposure duration and number of people exposed - the increase of the distance between sources and workers	• risk analysis • dose predictions • dose objectives • optimisation
6. Regarding the specific means related to external and internal exposure • means related to external exposure may be - collective means, fixed such as civil engineering or mobile such as shielding - individual means such as lead gloves or remote manipulator • means related to internal exposure may also be - collective means, such as confinement, ventilation and filtration - individual means such as respiratory devices The key points are • the description of the technical and organisational means, either collective or individual • the justification of the choices made: calculation hypotheses, suitability with sources and dose objectives, characteristics, location, effectiveness…	

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Key points	Approach involved
7. Regarding the dose objectives • the maximum annual individual dose. Corresponding objectives should cover both internal and external exposure and concern all categories of workers. Values proposed must be justified.	• risk analysis • dose predictions • optimisation
8. Regarding the training and classification of workers • the explicit mention of worker radiological categories • the radiological protection training required • consistent training with regard to the risks identified	• risk analysis • schedule of operations • dose predictions
9. Regarding the radiological zoning • the criteria and principles for radiological zoning • the justification of zoning with regard to the risk analysis • the marking out on the field	• risk analysis • dose predictions • experience feedback
10. Regarding the means for individual exposure monitoring • for external exposure - the types of dosimeters and their suitability as regards the radiological risks identified - the possibility of operational monitoring per specified task - the explanation of the possible alarm thresholds with the procedures to be applied in case of setting of these thresholds • for internal exposure - the existence of an individual monitoring - the description of the monitoring method set by physicians - the management of recorded doses with the description and use of measurements	• risk analysis • dose predictions • dose objectives • optimisation approach • experience feedback
11. Regarding the means for collective exposure monitoring • the description of fixed or mobile monitoring devices and their suitability as regards the radiological risks identified • the availability of the monitoring function • the justification of the possible alarm thresholds with the procedures to be applied in case of setting of these thresholds, location and maintenance of devices	• risk analysis • dose predictions • experience feedback
12. Regarding the structuring of experience feedback • the collection of information and how to use experience • the assessment criteria for structuring experience feedback: nature of data collection and eventual use	• definition of operating procedures • dose predictions • dose objectives • optimisation approach
13. Regarding the statistics on occupational exposure and surrounding exposures • statistics concerning internal and external exposure (collective dose, number of workers monitored, maximum individual doses, distribution of doses, doses to extremities if needed) with regard to the possibility of exploiting information • statistics concerning the dose rates and the levels of contamination, with the exeeding of alarm thresholds. • the assessment criteria are the representativeness of measurements • the possibility of exploiting the information	• risk analysis • dose predictions • dose objectives • prevention means • radiological zoning • monitoring means • optimisation
14. Regarding the events or incidents with radiological consequences • the identification of the lines of defence with those crossed over • the description of the event • the identification of causes • the description of compensatory actions • the consequences and experience feedback	• risk analysis • prevention means • radiological zoning • experience feedback

DECOMMISSIONING: PAVING THE WAY TOWARDS A DIFFERENT PLACE

By Craig Reiersen, Principal Inspector of Nuclear Installations, U.K. Nuclear Installations Inspectorate

Decommissioning is a natural stage in the life cycle of a nuclear facility, but a stage which brings particular organisational challenges. These challenges need to be addressed as part of a soundly considered and prepared decommissioning project.

The transition from operation to decommissioning brings new technical challenges, with the need to carry out invasive primary circuit work and to dismantle contaminated plant and equipment. However, the human and organisational challenges must not be underestimated. There are several different factors that need to be considered and addressed:

- the nuclear plants' staff members may be worried about their job security because decommissioning is usually associated with staff reductions;
- decommissioning may require staff to learn new skills and apply them in a new environment;
- decommissioning work requires a deep understanding of the plant. Capturing the "corporate memory" of the plant, and extracting relevant detail from experienced staff while they are still available becomes significant;
- a main goal of NPP operators is to produce electricity safely: but this "raison-d'être" is taken away with decommissioning, where the aim is effectively to dismantle a plant which the operators have worked for many years to sustain. This may present a strong psychological challenge to the operators' pre-existing goals and sense of purpose;
- decommissioning typically brings in a new and more extensive range of contractors. The ability to control and manage contractors effectively becomes increasingly important;
- operators may have to cope with political uncertainty. This was, for instance, the case in Sweden where a political decision led to the closure of one unit of the Barsebäck plant;
- management structures and management styles which work well for an operating plant may not be so effective for a decommissioning plant. The ability of management to flex their systems and styles to meet these changing demands is crucial.

Craig Reiersen, U.K. Nuclear Installation Inspectorate

› In search for certainty and confidence. Obviously, *uncertainty* is a key strand that runs through the above points. Any change process, if not properly →

➜ managed, can bring uncertainty, and uncertainty presents very real challenges to the morale and motivation of the workforce. It thus has the potential to impact adversely on the safety culture at the plant. Over and above dealing with the technical demands of the decommissioning process, a key part of decommissioning projects should consist of preparing psychologically for a new situation and trying to reduce the uncertainty experienced by staff. In this respect, I would suggest that communication is the most important factor. Early communication about job security can provide a powerful means of reassuring staff and retaining valuable workers. Providing those staff who will lose their jobs with support, education and re-training may help to reduce their concerns and contribute towards maintaining a positive safety culture in the interim.

In the UK, we have a Licence Condition (LC36), introduced a few years ago, which requires our licensees to put in place arrangements for managing change. The Nuclear Installations Inspectorate expects these arrangements to provide a systematic framework for analysing potential changes and for planning, managing and implementing the change process in a controlled manner, such that safety is not adversely affected. The transition of a plant from operation to decommissioning can be viewed as an example of major organisational change, and the change management arrangements should help the licensee to identify areas for consideration, and prepare a measured response, in a planned and controlled way.

The change management process should consider how the licensee can best retain an effective corporate memory. Every nuclear installation experiences many design modifications throughout its life cycle and not all of these changes – especially those which occurred a long time ago – are adequately recorded. Moreover, much relevant experience remains with operators and is not documented. An informed licensee should consider the information which it will need during decommissioning and take steps to ensure that this is correct, recorded and accessible some time before it is needed.

Looking beyond corporate memory, retaining the capability to behave as an "intelligent customer" is a pivotal issue for a well managed decommissioning project. Licensees cannot contract out their responsibility for nuclear safety. They must, therefore, retain the capability to operate as an intelligent customer. This means that they must, for example, be able to understand the safety case for their plant, specify contractual requirements, manage and control the contractors, interpret the results of contractors' work, etc. This has significant implications for a decommissioning project where large-scale use of contractors is common. ■

Spent-fuel storage facility.

NUCLEAR INSTALLATION DISMANTLING:
MAKING ONE'S WAY THROUGH THE TECHNICAL MAZE

By Friedrich-Wilhelm Bach, Director, Ralf Versemann, Chief Engineer, Head of Department Underwater Technology, and Peter Wilk, Chief Engineer, Head of Department Materials Testing and Corrosion; Institute of Materials Science, University of Hanover, Germany

The complexity of components from nuclear installations subject to dismantling or decontamination is substantive and so is the number of referring techniques. To choose the ideal technique and corresponding strategy, the most important criteria are costs, the amount and kind of radioactivity, aspects of radiation protection, the kind of material to be treated, its geometries and spatial accessibility. With respect to the requirements in decommissioning of nuclear installations, as, for example, remotely controlled applications, high process safety and efficiency, reduction of emission, dissemination and applicability under water, the number of usable techniques especially in the controlled area decreases.

By decontamination, a major reduction of waste for final storage can be achieved. During the selection of a suitable decontamination technique, focus is put on the material to be decontaminated. There are metallic, organic (paint, plastic coatings and parts, etc.), mineral (especially concrete) and ceramic (tiles, etc.) work pieces and surfaces. In general, decontamination techniques are based on chemical, electrochemical, mechanical and thermal mechanisms, as well as combinations of these. As with decontamination techniques, a large variety of dismantling techniques are state of the art and are currently in use.
In view of the wide range of dismantling tasks, many different cutting techniques have been developed, as shown below.

› Mechanical cutting and segmentation techniques. Mechanical cutting techniques with geometrically defined tool angles such as sawing and milling are characterised by rough and easily collectable residues (e.g. chips), high reaction forces and low cutting speeds. Mechanical cutting techniques with geometrically non-defined tool angles such as grinding and diamond wire sawing are characterised by process products consisting of small-grained dust (100-800 µm) in the atmosphere or slurry in underwater use.
Grinding units are electrically, hydraulically or pneumatically powered discs, suitable for the cutting of all types of materials. They may be used in atmospheric as well as underwater conditions. The maximum cutting thickness for metallic →

Friedrich-Wilhelm Bach, Institute of Materials Science

Ralf Versemann, Institute of Materials Science

Peter Wilk, Institute of Materials Science

➔ components is limited to 150 mm, mobile grinders used for dismantling tasks are not suitable for cutting stainless or mild steel thicker than 30 mm. Grinders can be operated remotely using video equipment. Problems are induced vibrations and reaction forces of the cutting disc as well as contamination control due to a continuous stream of sparks into the atmosphere.

Sawing can be used in the atmosphere and underwater. The tool is moved and supported by a feed unit. Fret saws are mainly used without coolants and lubricants for cutting depths up to 100mm. Bow saws are suitable for thin walled components with dimensions up to 1m cutting lengths, band saws for large-dimension components up to 3 m and circular saws for cutting up to 200 mm for metal and 500 mm for concrete structures. Diamond wire saws have been successfully tested for thick and reinforced concrete structures (biological shielding) up to 2,000 mm and for metal structures up to 300 mm. The main problems are the cutting kerf width and the resulting dispersion of contamination.

Shearing is used for cutting metals in form of sheet steel, pipes, bars and concrete reinforcement. The various processes can be divided into ever shears, circular shears, parallel shears and nibbling used for plate thicknesses between 1 and 30 mm for cutting lengths up to 4 m. Milling and orbital cutting tools are mainly used in atmosphere and underwater conditions for cutting cylindrical objects, such as pipes, tanks, etc. of diameters between 0.15 and 6 m. Research and development activities were carried out for the breaking of graphite structures using a straddling tool.

› Hydraulic cutting techniques. **Abrasive water injection jets** (AWIJ) and **abrasive water suspension jets** (AWSJ) with a maximum water pressure of 200 MPa can cut plate thicknesses of up to 132 mm. The advantages are the small amount of aerosol, a wide range of cuttable plate thickness, multifunctional use also for kerfing and delamination tasks, their suitability for work in the atmosphere as well as underwater, easy remote handling and low reaction forces. A disadvantage is the secondary waste emission, most of which are sediment particles.

Research and development activities are carried out in order to reduce the secondary waste as well as to design a process monitoring system and a modular hand-guided unit for abrasive water injection jet cutting.

› Thermal cutting techniques. **Oxy-fuel cutting** is restricted to mechanised, semi-remote as well as hand-guided dismantlings of mild steel or stainless steel plated mild steel structures. Therefore, mainly conventional cutting systems are used. In cutting tests, maximum cut thicknesses of 3,200 mm for steel and 1,200 mm for concrete structures could be achieved. An important disadvantage, especially for oxy-fuel-cutting with powder, is the high amount of aerosols produced during this process. Research and development activities are currently underway for high pressure oxy-fuel cutting and mechanised oxy-fuel cutting underwater, especially for cutting stainless steel plated mild steel structures.

The lance cutting process can only be used for drilling and perforation cutting, for example prior to oxy-fuel cutting of thick structures, e.g. pressure vessels.

Characteristics are a low cutting speed, a discontinuity in process, its unsuitability for automation and the high amount of aerosols produced during this process.

For decommissioning purposes, **plasma arc cutting** is the most commonly used thermal cutting technique for activated components, especially reactor internals. The main advantages are the high cutting speed over a wide range of plate thickness, its suitability in atmospheric as well as underwater use, easy remote handling and low reaction forces. Regarding the dismantling of highly activated core components, characteristic data of the amount and size of emissions are available. Research and development tasks are underway in order to reduce the kerf width in combination with designing a personal guided "steady-cut-system", as well as increasing cuttable plate thicknesses underwater and the investigation of plasma arc cutting in water depths of up to 20 m. Recent successful investigations were made for cutting 130 mm stainless steel in 4 m water depths.

Laser beam cutting is characterised by small cutting kerfs and precise cutting contours, small heat-affected zones, small tolerances, little distortion of the workpiece, stress-free treatment and high reproducibility. On the other hand, a high financial investment is necessary, and the low efficiency of lasers is coupled to high energy consumption. Laser technology can be used in dismantling many areas of Nuclear Power Plants such as tanks or storage basins consisting of concrete walls lined with steel plates. Current research and development activities are underway for the cutting of asbestos materials as well as the designing of modular laser beam cutting systems for cutting in the atmosphere and underwater.

Contact arc metal cutting (CAMC), drilling (CAMD) and grinding (CAMG) are electro-thermal cutting techniques, which cut conductive materials with Joule and arc heating.

- CAMC is currently used for separating, within a single cut, complicatedly designed components like tube-in-tube work pieces and components with re-entrant angles. State-of-the-art CAMC is currently cutting 260 mm thick components.
- CAMD was also developed as a new technology to drill holes or pocket holes without restoring forces. An automated fixing system was developed together with a warp mechanism.
- CAMG with a rotating electrode, offers new fields of application. Steel or carbon fibre reinforced graphite can be used as materials for the cutting electrode. The cutting speed is very high and the maximum cutting thickness is 40-50 mm. Research and development activities are carried ➜

Boiler cutting performed using fire protection clothing.

➔ out to reduce the electrode wear and to increase the maximum cutting thickness for contact arc metal grinding.

› Chemical techniques.

Electrochemical cutting techniques and electrical discharge machining, as well as microwave spalling, are used only for specific dismantling tasks and for decontamination purposes. Further on, explosive cutting, used for the delamination of activated concrete structures, has only a few applications in decommissioning tasks, for example as the dismantling of the biological shield. Arc saw cutting, working with a rotating disc, was used for dismantling of different reactor pressure vessels. Other arc processes are discontinuous oxy-arc cutting, as well as the consumable electrode oxygen and water jet cutting. Application examples for consumable electrode water jet cutting are the dismantling of pressure vessels and steam dryer housing. ■

Further information concerning the described technologies is available in the proceedings of the IAEA-conference in Berlin, October 14th-18th, 2003, as well as in the proceedings of the conferences "Jahrestagung Kerntechnik", KONTEC and "Stilllegungskolloquium Hannover" in Germany. Reports from the European Commission, for example the "Handbook on Decommissioning of Nuclear Installations", provide useful additional knowledge.

Cutting techniques

Mechanical/hydraulic
- Sawing
- Shearing
- Milling
- Breaking
- Grinding
- Nibbling
- (Diamond) wire sawing
- Microwave spalling
- Abrasive water jet cutting
- etc.

Thermal
- Oxy-fuel cutting
- Lance cutting
- Plasma arc cutting
- Consumable electrode oxygen jet cutting
- Consumable electrode water jet cutting
- Oxy arc cutting
- Arc saw cutting
- Contact arc metal cutting
- Contact arc metal drilling
- Contact arc metal grinding
- Laser beam cutting
- Electrical discharge machining
- etc.

Chemical/electrochemical
- Explosive cutting
- etc.

Dismantling of Chinon NPP (France).

SPENT FUEL & WASTE MANAGEMENT:
A KEY ISSUE FOR SUCCESSFUL DISMANTLING

By Claes Thegerström, Executive President, Svensk Kärnbränslehantering AB (SKB, Swedish Nuclear Fuel and Waste Management Co.)

**Spent fuel from nuclear reactors as well as waste resulting from reactor dismantling contains many radiotoxic elements and emits radiation. Therefore, any decommissioning and dismantling project is closely associated with the availability of a repository for the safe long-term storage of such materials. Back in the mid-70s, the Swedish Nuclear Fuel and Waste Management Co. (SKB) began work on developing a system to deal with radioactive waste. Sweden thus became the first country in the world to have an operating spent fuel management system.
The lessons learnt show how early and widely the spent fuel and waste management issue must be considered by any country embarking on a nuclear programme.**

A general trend in modern society is that siting activities have gradually become more and more complex, time-consuming and resource-demanding. Although this has probably increased the risk of extensive delays or even failure, it is probably the only way of reaching broadly accepted and implementable solutions.

One consequence for the organisation or the company in charge of siting is a major change in the size and composition of its personnel and expertise. While maintaining a high scientific and technical competence level, many new members of staff with a background in social sciences who possess appropriate communication skills have to be recruited.

There is a noticeable shift towards more explicit and comprehensive involvement and influence on the part of the local authorities in the siting regions. This in turn results in local demands for more visible support for the siting programme at the national political level.

Claes Thegerström, SKB

From the implementation perspective, a successful siting of a deep repository must build on two main cornerstones: firstly, a continued good performance of operating facilities and of R&D work to guarantee top-quality technical systems. This is also a prerequisite for retaining and increasing the faith shown by society in the nuclear waste management programme. Secondly, a transparent siting process based on voluntary participation by local authorities that fulfils the geoscientific, technical and social criteria set up for each phase.

› There's more than just technology involved. Traditionally, scientists and engineers have been accustomed to ➜

➔ solving their problems in peace and quiet, and being treated with respect for their professional competence. But the problems associated with radioactive waste from nuclear power go far beyond science and technology. Therefore, it is not sufficient simply to supply a constant flow of information along a one-way channel. An active dialogue between the organisation or the company in charge of siting and all parties concerned must take place with emphasis put on the development of a comprehensive environmental impact assessment as a basis for decision-making. In this process, priority should be given to individuals and small groups. Large meetings are normally a failure for all parties concerned. Try to meet with many small groups, only then is it possible to listen, discuss and make sure that the message is understood. Otherwise there is a risk of preaching to the converted if you only talk to those who already agree with your project.

Moreover, local feeling must be considered in areas regarded as possible sites for storage or disposal facilities. There are considerable differences in the attitudes of communities with longstanding industrial traditions and those with no industrial links.

› It is necessary to be didactic and open.

Simple wording. In any dialogue, it is vital to carefully define the problem to be discussed. Communication should concentrate first on why, and then on how. It should also pay particular attention to problem formulation. It is difficult, but essential, to present one's message using ordinary and familiar terms and concepts. The waste disposal concept, for instance, must be presented in a clear and comprehensible manner (for example, good visual material assists understanding). Otherwise it is impossible to express complicated scientific and technical facts to the general public.

The periods of time involved in radioactive decay are almost incomprehensibly long, and everything associated with radioactivity is therefore frightening to most people. As a result, it sometimes seems beyond our capabilities to solve the problem. But natural analogies can help defuse this problem. The fact that nuclear reactions are not something that was "invented" by crazy scientists and that high levels of radioactivity exist as a result of natural processes comes as a surprise to many people. The Oklo "reactor" is a good way of enhancing understanding.

And open-mindedness. It is easy to be suspicious of people who are not open about their plans. And it is very difficult to regain trust once it is lost. It should be

Storage of el4-type heat exchangers.

kept in mind that the opposing side often has an advantage in the ability to create strong images and symbols with great ease. It is therefore vital to be able to present counter-arguments to misleading statements and to defend your own views. Ethical arguments, such as the responsibility to future generations to seek the best possible solutions, need to be given sufficient emphasis and expression, since people are often more concerned about the moral/ethical aspects of the project, rather than its technical feasibility.

The siting project will be questioned, which is why the implementers must allow scope for possible changes or improvements to the project. Learn from these changes, many of which may be beneficial. You cannot be expected to know everything from the start and constructive criticism should be welcomed.

› Words cannot replace action. Trust or distrust will depend mainly on how an organisation is seen to behave: give priority to actions - they speak louder than words. Visits to operational sites are important in terms of moulding public opinion, since one would be hard put to find more believable carriers of the organisation's or the company's message than the people who actually handle the waste and its potential hazards. Therefore, people rarely disbelieve what they see with their own eyes, and practical demonstrations of how spent nuclear fuel can be handled help enhance confidence in future plans.

Moreover, reporters may be surprised to find that they are welcome to visit nuclear plants and facilities, since the industry has acquired an aura of secrecy and closed doors. Among key actions, relationships with local authority politicians and officials deserves special attention. A VIP visit should be arranged at each new site, with personal invitations to the members of these groups.

Other initiatives may include travelling exhibitions directed at schools. Special course material should be produced for this purpose, including educational material for teachers, and class visits arranged to the investigated sites.

› There has to be an "engine" for any siting programme to arrive at a decision. Few politicians may support the siting project publicly, even if they are willing enough to come and look at plants and listen to presentations. But politicians generally have great difficulty in working with issues that really lie beyond the scope of their present mandate. Regardless of how firmly they might believe in existing technology and its suitability, not many will join a campaign for something that lies decades ahead in the future if their electors seem to have different views.

Among the various stakeholders in the siting project, it is the role of the implementing organisation to provide the necessary thrust towards a decision. It is a difficult, sometimes frustrating but often stimulating task. Success requires flexibility and firmness, as well as both patience and impatience, and the ability to remain attuned to the specific circumstances encountered during the process. Press forward and don't give up. ■

SOME LESSONS LEARNT IN SWEDEN

By Torsten Carlsson,
former Mayor of Oskarshamn, Sweden

How can one make sure that a high-level waste disposal site is safe for 1,000 or even 100,000 years and that society will accept this solution? The experience gained at Oskarshamn shows firstly that a siting programme must be built on hard facts and evidence: science must be at the core of the programme, no shortcuts can ever be allowed in this endeavour and quality must always come before the schedule. Secondly, it shows that independent, active and competent regulators with the resources to review and challenge the implementation programme at every stage are necessary. The regulator should be the citizens' watchdog and always be part of the national and local debate. Thirdly, it shows that honesty and open-mindedness are a key issue. Operators must be open with all information, present it in an understandable way and allow for true influence by the communities and citizens. Industry should work with them, not against them or over their heads.

› Make stakeholders aware of the real stakes. Located in the coastal region of Kalmarlän, in south-eastern Sweden, Oskarshamn has a population of 26,000 inhabitants. Traditionally, tourism provides the local economy with a valuable income and is, therefore, a matter of concern for the local population and authorities.

Torsten Carlsson, Oskarshamn

Since 1992, the municipality has been one of the nuclear industry's key candidates for a radwaste repository system in Sweden. The experience gained there shows that high emotions were raised by nuclear waste. Firstly, it should be admitted that nuclear waste is an extremely hazardous material and that it may pose, if incorrectly managed, significant threat to health and safety for present - and future - generations. This is why a solution is in everybody's interest.
Secondly, every large siting project has major geographical consequences. It is a simple fact that plants must be located nearby local communities and will thus have effects on the individuals living there. Thirdly, final waste repositories must be sited where local communities are willing to give their consent to these facilities... for many generations! Experience has shown that, without this consent, the project will sooner or later be cancelled, stopped or indefinitely delayed - one way or the other. Therefore, siting must focus on three key issues: the safety of the repository system; the impact on local image and socio-economy; the importance of public acceptance and how it can be reached.

› Comply with some democratic principles. The experience gained at Oskarshamn shows that the principle of subsidiarity plays a major part in reaching public consent and should therefore be regarded as a cornerstone in the democratic development of a siting programme. In particular:
• the presentation of complete and understandable safety and environmental

impact assessments, developed in co-operation with the local communities, must form the basis for decisions;

• the necessity for a democratic dialogue at an early phase between the national assemblies, government or industry applicants and the local communities and public must be pointed out;

• the guarantee for comprehensive studies on image and socio-economic impacts, and economic compensations for both the municipality and the affected citizens, must be given.

› Get the decision making as close as possible to the impacted communities. In simple terms, the principle of subsidiarity can be summed up as the decentralisation of decision-making and as the need for a democratic dialogue on the local level. This means that decisions should be taken as close to the grass-roots level as possible. And few - if any - democratic organisations in Sweden are closer to the grass-roots than the local councils.

The times are not so far away when the siting of nuclear reactors was, almost without exception, decided following the "DAD principle", DAD standing for "Decide, Announce and Defend". Just a few decades ago, the power companies - public or industry owned - thus announced decisions already made behind closed doors, the report being flatly: "The plant will be located here". These previously made decisions were typically presented to local councils at a very late stage, leaving very limited possibilities for the affected local community to influence the project constructively. Some councils could say no through their veto, but most of the local communities in the world did not have this power and had to accept. Decades ago, the climate for these decisions was obviously very different from what it is today. At present, a much more sceptical attitude towards any large industrial project turned this practice into a disaster for all parties at all levels. Even if remaining "DAD" practices do still exist, hard work has mostly succeeded in replacing this method, in most countries, with much more openness and participation, simply because it was necessary.

Today, decision-makers must accept the lessons and avoid falling into such decision-making practices again. Instead, the industry should be urged to discuss its plans early, openly and thoroughly. This means much earlier than the industry thinks. Stakeholders at the local level must be invited and take responsibility to participate in and influence the project upstream, at the earliest planning stage.

› Provide for democratic and transparent dialogue. Industry must listen to local authorities and communities and respect them, just as the latter must listen to and respect industry. As a result of democratic dialogue, nuclear companies must be ready to change their plans to meet the expectations of the municipality and public affected locally. Industry's players must be willing to play an unbiased role to help the local communities pave the way for decision-making from a local perspective. Also, industry must further be prepared to accept that a no from the local community is a no! To the Swedes, the local veto is a very good basis for a fair and concrete application of the subsidiarity principle. In a sound decision-making framework:

• the demand is for an early local insight;

• transparency is paramount at each ➜

➜ stage from inception to completion of nuclear waste projects;
• local competence-building is an integral part of decision-making;
• the final decisions can only be made relying upon public consent.

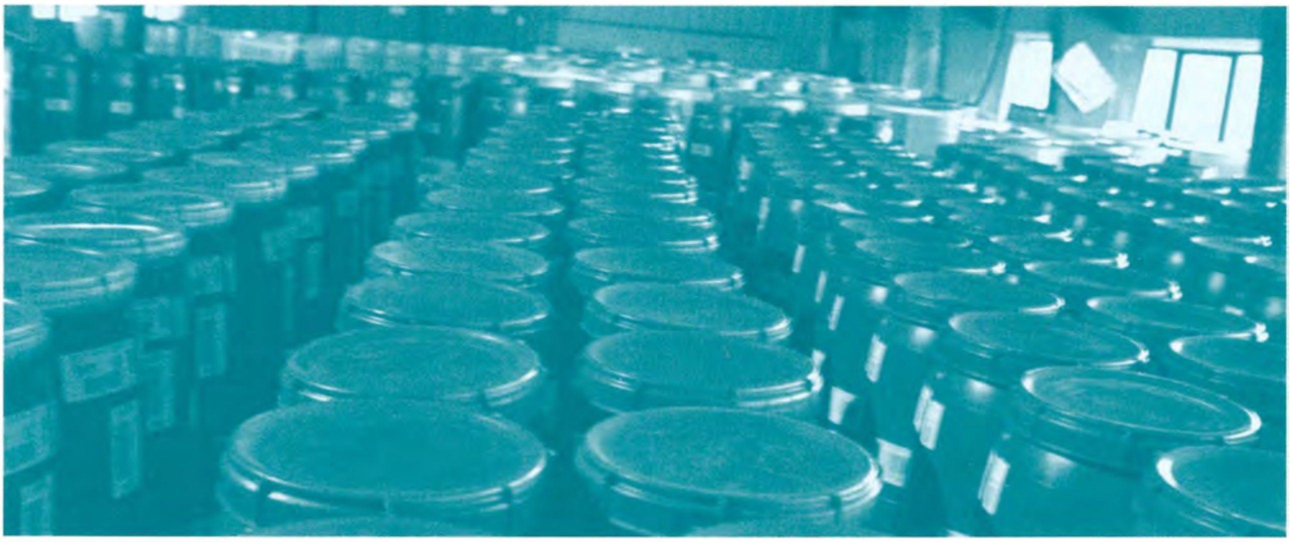
Local decision-makers should be aware that they must have informed public consent when they approve or reject energy-related projects. This may be perceived by industry as delaying a project or as mere additional costs, but they should be reminded of the many examples of local rejections in the past decades and asked what the costs have been for this! Put simply: is there any alternative to democratic and transparent dialogue and decision making?

› The "Oskarshamn model": openness and participation. The "Oskarshamn model" considers the public and environmental groups as resources and the environmental impact assessment as a platform for municipal participation. The working process includes all stakeholders with a view to developing a complete and relevant basis for collaborative decision-making, even if the decisions are made independently by each party.

The Oskarshamn working model contains seven components:
• openness and participation;
• the environmental impact assessment (the legal framework);
• the municipality council (the local "client");
• the public (a resource);
• the environmental groups (a resource);
• the regulatory authorities (the experts);
• the waste management company and the regulators (accountable for clear answers).

At Oskarshamn, local stakeholders have made tremendous efforts to form a local organisation with broadly representative working groups that almost knock on the doors of each citizen to engage them, to listen to their questions and to make sure that their concerns are voiced in council decisions. This way of working has ensured that decision-makers are walking hand-in-hand with the public who elect them and to whom they are responsible. ■

Storage of radioactive waste from dismantling.



HOW TO FINANCE A MAJOR INDUSTRIAL UNDERTAKING

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■ Electricity from nuclear power is produced at nuclear plants. Many of these have a long active life, on average forty years. Once the productive life comes to an end, it is necessary to deal with the removal of all the radioactive inventory generated throughout the operating life. This is in the form of waste. The goal is to allow the release of the site for alternative uses. This process is generically known as decommissioning. Given the very significant costs involved, the operator needs to take them into account when assessing the overall financial viability of a nuclear plant.

The operator will be required to build up financial reserves to cover these decommissioning costs during the productive life of the installation. This is normally done by including them in the cost of operation. Once sufficient reserves have been set aside to allow the safe decommissioning and management of radioactive waste and spent fuel, the fundamental issue is then to ensure the availability of these resources over a long period of time, as the process may extend for several decades after closure of the installation. The views of the EC on this subject are expressed below.

Estimating the costs of decommissioning

▼ Decommissioning a nuclear installation is a major industrial undertaking that can take many years and require considerable financial resources. In order to ensure that safety and radio-protection obligations will be fulfilled after closure, these resources will have to be provided for by the operator during the active life of the nuclear installation. It is essential that decommissioning operations can begin immediately after closure to ensure a high level of safety. It is also essential to avoid any possibility that the decommissioning of a nuclear installation will not be able to start as planned, is not performed according to the appropriate procedures or is abandoned before completion due to a lack of resources.

Many studies have been carried out by the nuclear industry and related bodies on the estimation of the costs of NPP decommissioning. Additionally, the experience accumulated from real decommissioning projects carried out during the last decades have informed the studies, thus helping to validate the assumptions of the studies and to improve the methodology for the estimations.

▼ The nuclear sector considers that the costs of the decommissioning activities of a particular power plant can be estimated with a high degree of accuracy, and that the remaining uncertainties can be clearly identified. It has to be noted, though, that many studies of decommissioning costs do not consider the costs of the complete management of the radioactive •••

●●● waste and spent fuel, which would include the disposal of the waste, either insitu or in a dedicated waste disposal site. Very dependent on factors of scale, the radioactive waste and spent fuel management costs may even represent a higher share of the total decommissioning cost than that of the dismantling of the installation. In some countries the costs of the complete management of the radioactive waste are still subject to very significant uncertainties, if only because not all the decisions on technology for waste treatment, routing and/or disposal of waste have been taken.

▼ In this respect, the Commission considers the geological disposal of high-activity waste as the safest and most sustainable technique given the state of the art.

The position of candidate countries

▼ Three candidate countries - Bulgaria, Lithuania and Slovakia - have reached an agreement with the European Union concerning the early closure of some of their nuclear reactors. These reactors will be shut down between 2002 and 2009, and the decommissioning activities will start accordingly. The EU is committed to help fund the costs of decommissioning of these installations. The instrument that is used for such support is the PHARE programme. The Community is the main contributor to the International Decommissioning Support Funds, which are managed by the European Bank for Reconstruction and Development (EBRD). There is an International Fund for each of the plants involved: Kozloduy, Ignalina and Bohunice.

DECOMMISSIONING COST ESTIMATES

• The cost estimates below cover the following activities carried out during decommissioning:
- Plant shutdown, decontamination, dismantling and demolishing down to industrial-use level (brownfield end point).
- In-situ radioactive and conventional waste management.
- In-situ storage of spent fuel.

• The four most common types of reactors are considered:

Pressurised Water Reactors, PWRs (USA, EU)
- Decommissioning costs range from 200 to 500 €/MWe.
- The reference value of 15% of initial plant investment that has been widely used in Western estimations lies within this range.

Boiling Water Reactors, BWRs (USA, EU)
- Costs are higher (around 10% more) than in PWRs due the greater amount of contaminated components.

Light Water Reactors, VVER (Russia)
- Decommissioning costs of up to 600 €/MWe.
- There are country-specific factors that may have a sensitive impact on the estimations.

Gas Cooled Reactors, GCRs (mainly UK and F)
- Estimations may reach 2,500 €/Mwe, but there are important differences between countries and the selection of the final solution for some of the waste (i.e. graphite) will have an impact on the overall costs. The recently accomplished dismantling of Vandellós I (Spain) is a very good reference. The plant has been decommissioned to stage 2 (reactor building left in safe store condition for a long period) for some 700 €/Mwe.

Guaranteeing the availability of assets to cover the costs of decommissioning

▼ Arrangements for funding the decommissioning of nuclear facilities must differentiate between non-commercial and state-owned facilities, such as early R&D facilities and demonstration plants on the one hand and commercial nuclear facilities on the other. In the case of state-owned facilities, the costs of decommissioning fall to the state. In the case of commercial nuclear facilities, the responsibility for providing the necessary financial resources for the future decommissioning and waste disposal resides with the operator. In all the EU countries it is a requirement, established either directly in legislation or by way of operating licences, that operators create and maintain funds or financial guarantees for this purpose. These funds are created from business revenues and, in almost all cases, the size of the necessary fund is reviewed - and, if needed, revised - on a regular basis, generally between 1 to 5 years.

▼ The way in which decommissioning funds are accumulated and managed varies from country to country. In some countries, as is the case in some Member States of the EU, the calculated sum for decommissioning is accumulated year by year over the whole planned lifetime of the facility. In other countries, other methods may be used, such as requiring the money be collected over a shorter period than the expected lifetime of the plant or obliging the licensee to make a down payment for all future decommissioning costs as a condition for obtaining the first operational license. In this way, some of the risks associated with a premature shutdown of the facility may be reduced.

▼ The ownership of the funds varies from one country to another. In some countries, such as Germany and France, the operators are allowed to accumulate and manage their own decommissioning funds, which remain in their own accounts; while in other countries such as Italy, Finland, Spain or Sweden, the funds are collected from the operators or the electrical system and managed by separate, independent bodies.

▼ The coordination of the national systems within the European Community framework could help to guarantee the maintenance of a high level of safety in nuclear facilities. With particular regard to the decommissioning of nuclear facilities, the proposal of the Directive setting out Basic Obligations and General Principles on the Safety of Nuclear Installations outlines the Community's approach to the establishment, management and use of decommissioning funds. The clearly stated objective in the proposal is that the funds have a legal identity separate from that of the funds of the nuclear operator. This fund must be able to guarantee the availability of sufficient resources to carry out the decommissioning operations when they are required. They should also be sufficient to guarantee that the decommissioning can be carried out to a level of safety that protects the general public and the environment from ionising radiation. ●

Dismantling of Brennilis NPP (France).

VENUES & WEBSITES

UPCOMING MEETINGS ON NUCLEAR SAFETY AND DECOMMISSIONING

➤ *10-13 November 2003 Luxemburg*
Fisa-2003: EU Research in Reactor Safety
Organised by Euratom

➤ *10-14 November 2003 Santiago, Chile*
International Conference on Research Reactors: Safety, Utilization, Decommissioning, Fuel and Waste Management
Organised by Euratom

➤ *23-28 November 2003 Avignon, France*
International Conference Decommissioning Challenges: an Industrial Reality?
Organised by SFEN. For further information: www.sfen.fr/avignon2003/

A FEW WEBSITE LINKS FOR READING MORE ABOUT DECOMMISSIONING

➤ **The Regulatory Challenges of Decommissioning Nuclear Reactors**
Published by OECD NEA
http://www.nea.fr/html/nsd/reports/nea4375-decommissioning.pdf

➤ **Fact Sheet on Decommissioning Nuclear Power Plants**
Published by US NRC
http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/decommissioning.html

➤ **The Decommissioning and Dismantling of Nuclear Facilities in OECD/NEA Member Countries: a Compilation of National Fact Sheets**
Published by OECD NEA
http://www.nea.fr/html/rwm/wpdd/

➤ **The Decommissioning of Nuclear Facilities World Nuclear Association**
http://www.world-nuclear.org/wgs/decom

The next EUROSAFE Forum will be held in Paris on 25 and 26 November 2003 focusing on Nuclear Expertise and the Challenge of EU-Enlargement

The fifth issue of the EUROSAFE Tribune will contain reports about the lectures and discussions of the Forum

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