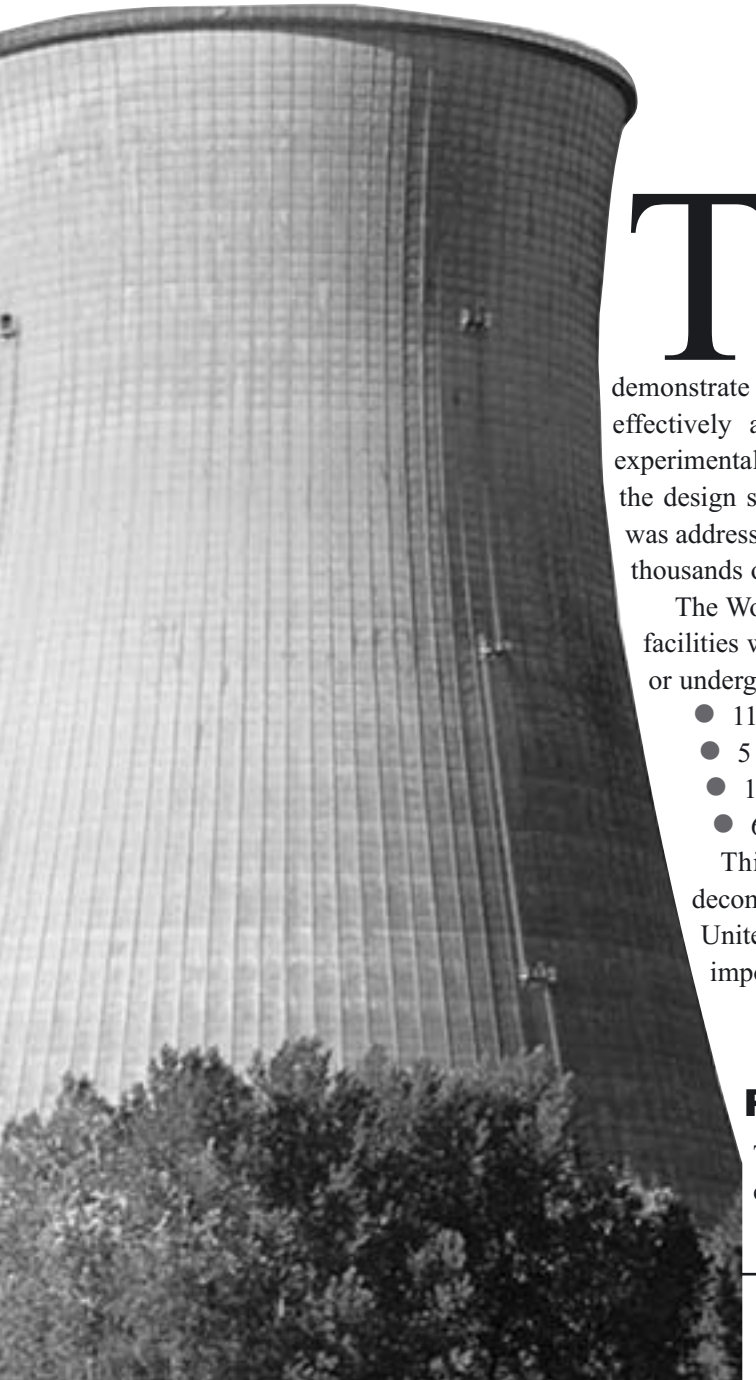
Decommissioning:

LESSONS TO LEARN

by John McKeown

Sharing experience and working together is important to allow the world nuclear community to respond to the challenge of restoring nuclear facilities safely, and cost effectively.



The decommissioning of nuclear plants and facilities is becoming an increasingly significant global activity as many of the world's nuclear facilities reach maturity. Carefully planned decommissioning is necessary both to remove the potential hazards from redundant nuclear plants and to demonstrate that environmental restoration of modern plants can be effectively and safely managed. Today's ageing facilities range from experimental plants where environmental restoration was not considered at the design stage to more modern power reactors where decommissioning was addressed at the design phase. The total worldwide cost is estimated at thousands of billions of dollars.

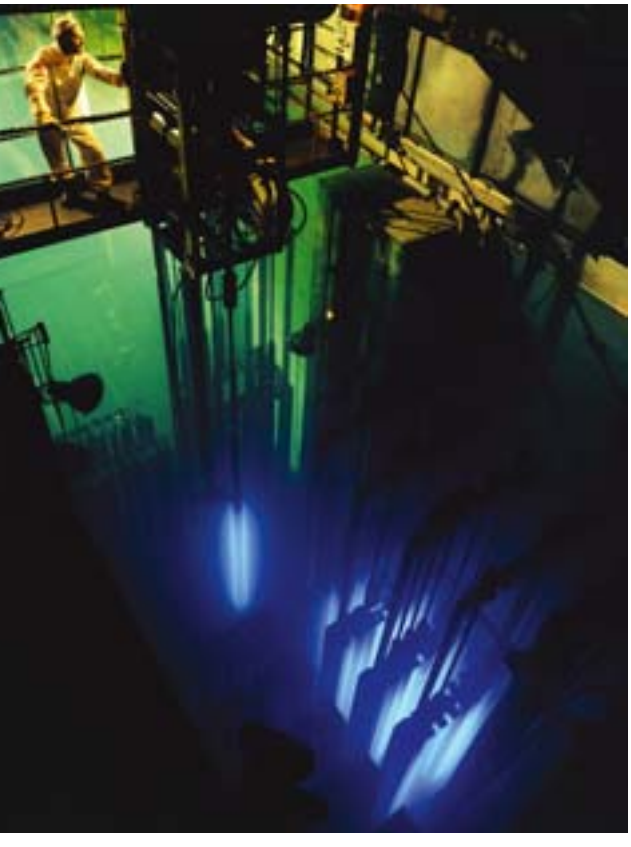
The World Nuclear Association Database (WNA) summarises nuclear facilities which have been retired from operation and are either awaiting or undergoing decommissioning as:

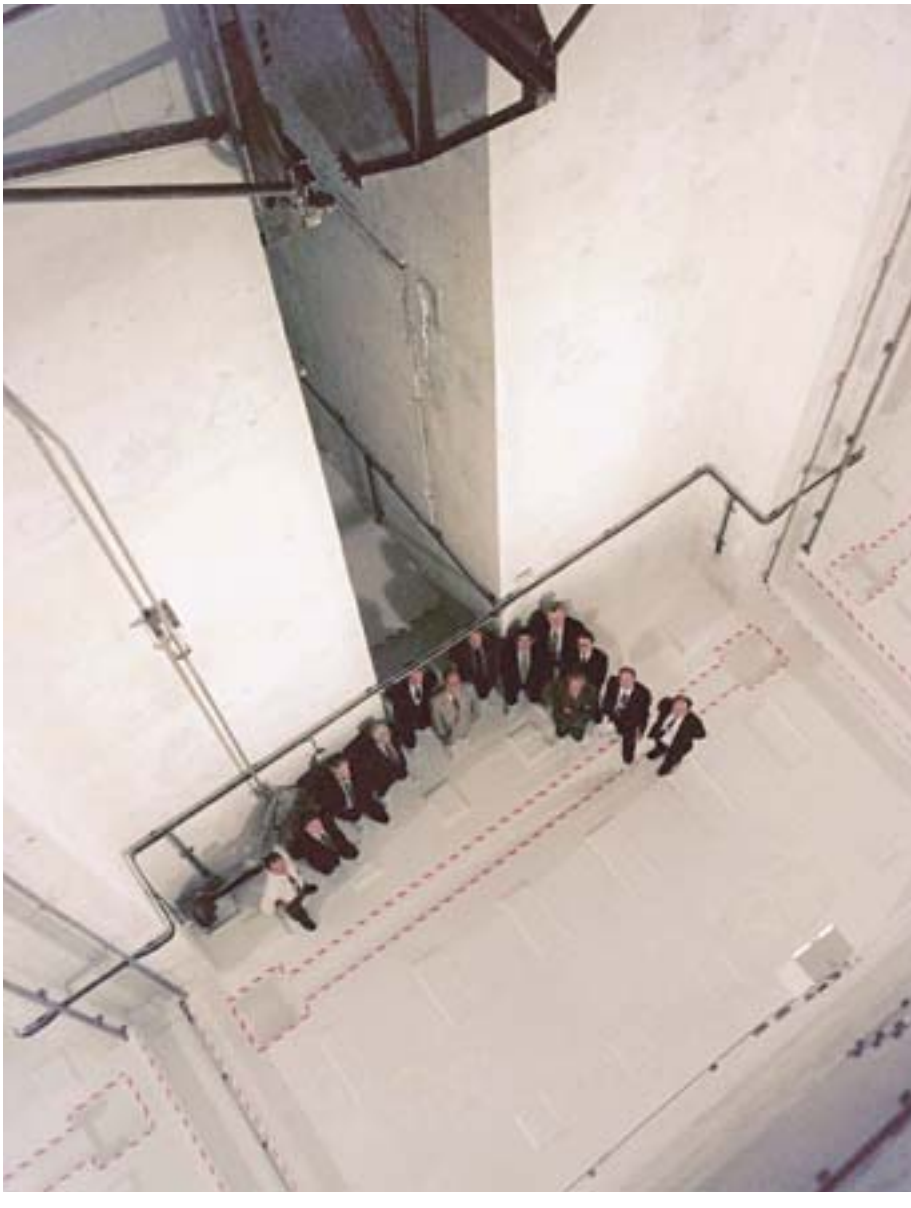
- 115 power and research reactors;
- 5 reprocessing facilities;
- 14 fuel fabrication plants;
- 60 mines

This article highlights key issues facing international decommissioning programmes drawing on the experience of the United Kingdom Atomic Energy Authority (UKAEA) to illustrate important lessons for the industry.

Project "Know-how"

The methodology, organisation, project management skills and contract strategies required for nuclear site restoration are





(Top) Before:The fuel pond at the Steam Generating Heavy Water Reactor at Winfrith, when the reactor was operational;
(Right) After: Visitors view the fuel pond at Winfrith, which was successfully drained and decontaminated.
(Credit: UKAEA)

becoming well understood within the nuclear community, particularly in Europe and the United States. Countries are sharing knowledge to address particular decommissioning problems, such as Chernobyl and the BN350 reactor in Kazakhstan. This expertise contributes to achieving sustainable development in that it does not compromise the ability of future generations to meet their own needs.

The complexity of larger nuclear sites with several reactors, associated fuels and waste plants, has resulted in the industry adopting integrated strategies for environmental restoration. Sites such as Rocky Flats in the US and the UKAEA Dounreay site in Scotland have developed integrated decommissioning plans using a combination of standard project planning software and specialised in-house software packages. The work is prioritised to remediate the more significant hazards at an early stage in the programme while ensuring that resource and cost profiles are optimised to remain at realistic levels to achieve best value for money. Coupled with studies that show the preferred technical options, this approach matches the time profile of waste arisings to the requirement for new waste stores and disposal facilities.

A focus on project delivery, with rigorous progress reporting, is key to successful decommissioning management. Accepted best practice requires costs to be accurately monitored against baseline decommissioning project work plans.

Waste Management

Detailed planning is essential to manage waste to meet existing and final disposal requirements. Segregation at source is recognised to minimise cost and resources. Good

management practice ensures that no waste stream is generated until a strategy for its conditioning, storage or disposal has been defined. Whilst this can be difficult in the absence of a final waste site independent of the waste producer or owner should make a considered judgement on the likely acceptability of the proposed standard and the likely suitability of each waste form to meet those standards.

Legacy wastes can present particular problems. This material is often in a complex heterogeneous form, which may be difficult to handle, categorise and assay to the increasingly detailed characterisation requirements of store and repository operators and regulators.

Training Together

The shortage of staff qualified and trained to carry out nuclear site restoration is proving to be a Europe-wide issue. Accepted best practice recognises the need for greater cooperation between industry and academics in training and educating for the relevant disciplines.

There are positive signs that this is being addressed in Europe. EC Framework Programmes support the establishing of networks and consultative committees. Proposals for a European Masters Degree in nuclear engineering have been considered by the European Atomic Energy Society.

The UK Department of Trade and Industry is leading a Nuclear Skills Initiative which involves industry, regulators and academics. UKAEA sponsors a postgraduate course in nuclear decommissioning at Birmingham University. A new higher education institute in the north of Scotland, covering the Dounreay geographical area, the University of the Highlands and Islands Millennium Institute (UHI), is forming appropriate links with other European educational centres. These include the Institut National des Sciences et Techniques Nucléaires (INSTN) in France, centres in Rome and Ljubljana as well as the US national laboratory at Idaho Falls.

On the industrial front, exchange programs involving nuclear engineers are taking place. UKAEA has hosted engineers from France, Kazakhstan and Lithuania to work alongside its own professional engineers. A French company is sponsoring the admission of engineering students to UHI.

The Regulatory Position

The progressive removal of hazard is the key issue in the environmental restoration of legacy nuclear facilities - whether reactors, chemical plants or other facilities. This work has to be carried out safely and within the boundaries of an approved safety case appropriate to the work. While an operating safety case is concerned with a safety justification based on today's conditions with short-term costs and benefits, the safety case for a long-term decommissioning project has to be justified on the basis of sustainable development and conditions for future generations.

Common sense dictates that the decommissioning of similar nuclear facilities worldwide will benefit from sharing experiences, achievements and even failures.

The regulatory view is evolving to recognise that decommissioning often consists of a series of decontamination and dismantling packages which can be controlled by risk assessments, method statements and peer reviews. The decommissioning safety case should therefore be a strategic document which analyses the hazards and the separate stages required for hazard reduction. This view also recognises that during decommissioning, short-term risks may increase in order to achieve the long-term reduction in hazard.

Worldwide Industry Collaboration

Common sense dictates that the decommissioning of similar nuclear facilities throughout the world will benefit from sharing experience. The immediate and future decommissioning of the world's fast reactors must have many common issues and the industry is now surely mature enough to share its problems and solutions.

Several very positive steps have already been taken to achieve this: the Nuclear Energy Agency (NEA) working group on decommissioning is well respected and

GLOBAL LESSONS FOR NUCLEAR SITE RESTORATION

The lessons learnt from the UKAEA experience have direct relevance to worldwide decommissioning and nuclear site restoration.

The technical and project issues are:

Programme management
A complex multi-project programme must be effectively managed taking into account the entire project interfaces and interactions. Commercially available proven software should be used wherever practical.

Waste management
Waste streams require to be properly specified to allow the development of appropriate treatment and disposal routes. Segregate waste streams at source.

Staff experience
Decommissioning should commence when operations cease in order to make full use of available expertise and the detailed knowledge of the staff who operated and maintained the plant.

Waste handling
Wastes should be packaged to modern standards which have been accepted by waste disposal organisations.

Legacy wastes
The timescale for implementing decommissioning works should carefully consider the benefits of delay. Where delay will result in reduced levels of radioactivity, which may permit manned entry, the benefits of simplicity and efficiency should be realised. Where no such benefit arises, early decommissioning allows the use of staff with detailed knowledge of the plant which will increase the efficiency of the process.

Power reactors
The decommissioning of some types of power reactors will be simpler and cheaper over time if short-lived isotopes, such as cobalt 60 in steel, decay over time, to permit man access to implement works. Where such a case can be made it must be explained to the public in a clear language to avoid public antipathy to the delay.

Engineering complexity
Keep it simple. Use human access, where radiologically safe, for jobs that are very complex for a machine. Do not design equipment for lifetimes longer than the task duration.

Systems management
Implement a management system to provides an audit trail which complies with an internationally recognised standard.

Training
There appears a general shortage of adequately trained personnel for the foreseen worldwide decommissioning – almost certainly as a result of the lack of construction of nuclear plants. The available knowledge must be shared to reduce the overall costs of these works and should form part of the knowledge base which is passed onto the younger members of staff who are being recruited for decommissioning works.

Stakeholders
Maintain a full dialogue with regulatory and other stakeholders and discuss proposals for the way forward.

International collaboration
It is important to encourage working level links with similar projects in other countries and benchmark your activities against others' comparable programmes. Share technologies and systems to drive down costs – to make decommissioning faster, cheaper and safer.

encourages free and open discussion; the World Association of Nuclear Operators (WANO) Group Meetings on fast reactor decommissioning are equally valuable. The IAEA has international teams that produce excellent technical documentation and the European Atomic Energy Society helps produce consensus views on a range of pertinent issues across Europe. Major international conferences encourage participation by a wide range of attendees from across the industry. UKAEA has established a number of more formal collaboration agreements with European and US organisations to mutual benefit.

Environmental Restoration in the UK

The United Kingdom Atomic Energy Authority is a public sector body that was established to pioneer the development of nuclear power in the UK in 1954. Now that the initial programme on fission reactors has been completed, it is spearheading new approaches to the decommissioning and environmental restoration of its nuclear sites for conventional use. UKAEA also maintains an active programme on fusion research at its Culham site in Oxfordshire, including the Joint European Torus (JET) facility, which it will also be responsible for decommissioning.

The UKAEA Environmental Restoration Programme is spread over five sites in the United Kingdom. Each site has different reactor types, ranging from early experimental piles to thermal and fast power reactors with the full spectrum of supporting fuel manufacturing and processing plants, waste handling plants and laboratories. The biggest decommissioning challenge for UKAEA is at the Dounreay site where restoration work is presently estimated at £4.3 billion (7 billion Euros) and due to be completed within 60 years.

Decommissioning a nuclear site requires careful analysis of possible options, detailed planning and effective waste management. UKAEA has developed sophisticated software systems to analyse possible decommissioning scenarios and present the financial, resource and waste management consequences of each option. This software analysis has been applied to all our sites which are the locations for a wide range of conditions and plants. The Dounreay Site Restoration Plan, published in October 2000, is the most detailed environmental restoration plan for a complex nuclear site anywhere in the world.

The programme requires high standard safety documentation, together with the development of safety standards and processes for peer review including expert independent assessment. UKAEA prepares a wide range of safety documentation and operational procedures to meet the requirements of nuclear and environmental regulators.

Contract Strategy

UKAEA policy is to achieve value for money by specifying work to the level necessary to allow companies to compete to implement the work under contract. The form of contract reflects the requirements of individual projects. Alliance, consortium, traditional or prime contractor strategies are considered in determining the optimum value for money.

The Winfrith Operations, Maintenance and Decommissioning (WOMAD) project is a nine year project, signed in 2000, which signalled a new way of working with a contractor. This strategy aims to build a close client-contractor relationship the success of which is now bearing fruit.

At Dounreay's Prototype Fast Reactor, an alliance contract was established between UKAEA and four contractors to tackle the difficult problem of removing residual metallic sodium from fast reactor components and vessels. The concept of all parties working together and helping each other to solve problems, coupled with appropriate incentives, has proved very successful.

Progress and Prognosis

UKAEA has decommissioned 13 reactors and seven major radioactive facilities. This experience illustrates the benefits of implementation decommissioning works whilst detailed knowledge of the plants is available and before the plants start to deteriorate.

Efficient waste management is key to successful environmental restoration. This requires a coherent waste strategy, a valid safety case, substantiated operational procedures and thorough operational records.

At Dounreay this is being achieved through the Dounreay Radioactive Waste Inventory. At the next level up, the Dounreay Radioactive Waste Document provides an authoritative source of strategic data on radioactive wastes. This includes a description of each waste stream, its properties, a history of the strategy, for dealing with the waste, the current plans and programmes, and threats to their delivery. At detailed level, the Radioactive Waste Inventory is based on Waste Stream Characterisation Documents. Each waste stream has a description of the process which produced it, the expected volumes and time scales for production, a full physical, chemical, radiological and toxic breakdown of the waste. The relevant data is produced to appropriate quality standards.

The recently commissioned Waste Receipt Assay Characterisation and Supercompaction plant, (WRACS) for low-level solid radioactive wastes at Dounreay is an example of a newly developed waste route. This facility takes in solid low-level waste (LLW) from site operations, packed in steel drums, and prepares it for interim storage or disposal. The drums are radiographed to check the contents and assayed for levels of radioactivity using sensitive equipment which is calibrated daily. The accepted drums are then compacted in a 2000t press that reduces the volume by a factor of five. This plant ensures accurate record keeping of LLW on site, an essential part of safe waste management.

At UKAEA's Harwell site in Oxfordshire, intermediate level wastes, first stored some 50 years ago in below surface storage tubes, are now being removed using remotely operated technology prior to being characterised, repackaged and stored to modern standards in a retrievable above ground store. A 100t mobile and shielded Retrieval Machine has been designed, developed and installed to recover the aged waste containers and their contents. The complexity of the task is aggravated by the original containers suffering corrosion which has resulted in loose debris in the storage tubes which must be recovered. This project has demonstrated the benefits of very detailed analysis of the expected life of storage facilities and the development of recovery equipment capable of retrieving material should there be a leak from any container.

The Advanced Gas-Cooled Reactor at UKAEA's Windscale site in Cumbria is being decommissioned to

Intermediate level waste store at Dounreay. (Credit: UKAEA)

provide experience for decommissioning the UK's commercial Advanced Gas-Cooled Reactors. A range of sophisticated remote operation devices has been developed to enable this work to be completed safely within the programme dates.

The Dounreay Fast Reactor (DFR) and Prototype Fast Reactor (PFR) are being decommissioned to an advanced stage using specialised remote handling techniques. Equipment has been developed to drill through part of the reactor internals of PFR and to pierce specified primary sodium pipes within the reactor vessel to facilitate effective draining of liquid sodium. Sections of the internals of DRF will be machined to permit removal of jammed breeder elements. Remote operations have been developed and tested in mock-up facilities which will be retained throughout active operations to facilitate the analysis and solution of problems.

Whilst remote controlled equipment is necessary for some decommissioning works manual operations should not be discarded without proper consideration. A skilled operative trained in a specific task can often carry out the works safely and quickly, with an acceptably low exposure to radiation. Simplicity has an important part to play in the safe decommissioning of the most complex plants.

The industry has lessons to learn. New techniques may be used where a novel approach is required. But commercially available equipment should be used and adapted wherever practical.

The environmental restoration of sites with nuclear plants will be a major area of activity for the nuclear industry. Sharing experience and working together will allow the world nuclear community to respond to these challenges safely, environmentally responsibly, effectively, promptly and provide enhanced value for money.

Dr. John McKeown was a panel member at the IAEA Scientific Forum in 2002 that examined decommissioning and other topics. He is Chief Executive of UKAEA. Prior to his appointment he was with Scottish Nuclear as Director of Health, Safety and Licensing. E-mail: John.McKeown@ukaea.org.uk. To learn more about UKAEA visit www.ukaea.org.uk. To read more about the IAEA Scientific Forum, go to http://www.iaea.org/worldatom/About /Policy/GC/GC46/SciForum/