French Atomic & Alternative Energies Commission Decommissioning Policy and Strategies: What is at Stake Lessons Learned & Feedback Experience – 15013

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ABSTRACT

Since its creation in 1945, the French Atomic Energy and Alternative Energies Commission has carried out research programmes on civil use of nuclear, and its application. CEA has set up and run various types of installations from research (accelerators, pond reactors, fast reactors, laboratories) to industry (power reactor, processing facilities). There are currently more than several tens of facilities which are presently closed down pending dismantling or in the process of being dismantled by CEA, the governmental body for research and development in nuclear and renewable energies.

When operating, all these installations have generated radioactive waste. When they are shutdown, either as a result of the programmes for which they were set up, or due to equipment wearing out or being obsolete, these installations must be cleaned up, dismantled and decommissioned, taking into account their nuclear nature and requirements related to safety and environment. During the decommissioning process, the implementer has to deal with safety and site remediation issues. Dealing with these installations is a long-term programme which must be carefully planned and financed in order to optimise its management.

The paper will describe the CEA's decommissioning policy, strategies adopted, and draw up lessons learned and feedback experience, showing that:

- Safety is guaranteed,
- Dismantling is a technically controllable operation, but R and D actions are to be developed for specific problems as characterization or operation in hostile environment. Moreover all the methods and techniques improve as a result of feedback experience,
- The amount of material and waste produced by the dismantling are manageable. The very low, low and intermediate level waste can be stored on existing shallow land burial centres, some new repositories have to be created for specific waste (graphite, radium, …) and for high and intermediate level long live waste, which are stored in interim storage ,
- The dismantling must be optimized, especially by appliance of a good strategy based on rational industrial choices.
- Communication and transparency with stakeholders is essential for global process acceptance,

– The lessons learned and how feedback experience could benefit for future decommissioning projects.

INTRODUCTION

Since the French Atomic Energy Commission (CEA) was founded in 1945 to carry out research programmes on use of nuclear, and its application France has set up and run various types of installations: research or prototypes reactors, process study or examination laboratories, pilot installations, accelerators, nuclear power plants and processing facilities. Some of these are currently being dismantled or must be dismantled soon.

Since the 1960s and 1970s in all its centres, the CEA has acquired experience and know-how through dismantling various nuclear facilities. The dismantling techniques are nowadays operational, but certain specific developments are necessary to reduce the doses integrated by operators, the cost of operations and to minimize delay and waste volume. Thanks to availability of techniques and guarantees of dismantling programme financing now from three-year agreement signed with French government,, close to € 11,000M for the next thirty years, for current or projected dismantling operations, the CEA’s Nuclear Energy Division has been able to develop, when necessary, its immediate dismantling strategy. Currently, more than twenty facilities are being dismantled by the CEA's Nuclear Energy Division operational units with industrial partners. Thus the next decade will see completion of the dismantling and radioactive clean-up of the Grenoble site and we pursue the dismantling of the facilities on the Fontenay-aux-Roses site and of the UP1 plant at Marcoule, the largest dismantling work in France, which is well advanced, with most of the process equipment dismantled.

After an overview of the French regulatory framework, the paper will describe the DD&R strategy, programme and feedback experience inside the CEA's Nuclear Energy Division.

CONTEXT AND BACKGROUND

The CEA's Nuclear Energy Division (DEN) nuclear facilities currently include several research reactors and other miscellaneous facilities, particularly laboratories, fuel processing units and facilities specific to waste management.

Some of these are currently being dismantled or must be dismantled soon.
At CEA, the first nuclear facility dismantling operations go back several dozen years and involve numerous and varied facilities. The first operations of any significance took place in the 1960s and 1970s and covered, for example, the first plutonium plant at Fontenay-aux-Roses (total

dismantling) and small research reactors or critical models -. At La Hague, the dismantling of AT1, a pilot workshop used by the CEA during the 1970s to process irradiated fuels from fast neutron reactors, was completed in March 2001 (IAEA former stage 3, excluding civil engineering demolition). On the other hand, during this period of first dismantling, the intermediate-sized reactors (G1, Rapsodie) were partially dismantled after shut down, mainly due to the lack of graphite and sodium waste management routes at the time.
About twenty facilities were thus dealt with up to 2001.

Although the first dismantling operations proceeded at a steady pace, the same was not true during the 1990s, when the dismantling plan was slowed and very few sites could be completed. This was due firstly to evolutions in regulations, which induced modifications of the dismantling process, and secondly funding difficulties.

In June 2001, the CEA decided, consistent with the supervision governmental authority, to create a specific fund for the dismantling and clean-up charges of its civil facilities, with an initial allocation from industrial funds, from payment of an exceptional dividend from AREVA and from a portion of the AREVA shares held by the CEA.

For the dismantling of nuclear facilities in the "Defence" sector managed by the Nuclear Energy Division, exclusively the facilities inside the UP1 reprocessing plant at Marcoule, a specific "Defence" fund was created in 2004 within the CEA, fed initially by final instalments from EDF and COGEMA from the portion due given their past participation in the plant's programmes. Note that for both the civil and defence sectors, law n°2006-739 of 28 June 2006 on the sustainable management of radioactive materials and waste, and its application decree n°2007-243, henceforth impose the constitution of provisions and fix the modalities for use by the governing bodies to make sure that the funds required for dismantling current and future nuclear facilities are both lasting and available at the right moment.

CURRENT REGULATORY FRAMEWORK AND PHASING OF DISMANTLING OPERATIONS

In 2006 and 2007, Law n°2006-686 on transparency and safety in nuclear matters and its application decree n°2007-1557 on nuclear facilities set the current regulatory framework relating to the dismantling and decommissioning of licensed nuclear facilities, two guides were issued in 2010 on Methodology for nuclear facilities post operation and DD&R operations and Methodology for total clean-up.

The various dismantling phases are now preparing for final shutdown, actual dismantling and decommissioning, as specified below.
A nuclear facility operator wishing to shut down his facility permanently must henceforth advise the Safety Authority. This information, which must be lodged at least three years before the date on which the operator intends to start the dismantling operations, is supported by an updated plan of the facility dismantling. In addition to presenting the preparations for the final shutdown, this plan must in particular describe and justify the dismantling strategy, the sequence of operations and the equipment required the planned waste management outlets and the targeted final state of the facility after dismantling.

This information on shutting down a facility's operation is the start of the so-called preparatory phase for final shutdown. This transition stage, in the context of the facility's operating licence, sees the evacuation of all or part of the source term - evacuation of fuel in a reactor or emptying of process circuits in a laboratory, for example. This is also the stage for preparing for dismantling operations: evacuation of equipment scheduled for removal in the safety reference documents, creation of radiological inventories, site preparation, training teams, etc. The actual dismantling phase follows on from the preparation phase; this aims, in the event of total dismantling, to dismantle and evacuate the operational equipment and structures in the facility, including those parts which acted as radioactivity containment barriers. This phase requires further administrative authorisation subject to public enquiry.

At least one year before the planned final shutdown, the plant operator submits the authorisation request to the Ministers responsible for safety.
After examination by the Safety Authority and acceptance of proposals made by the operator, including those relating to the final state, the authorisation is issued as a decree setting especially the dismantling timescale.

Decommissioning of the facility, removing it from the legal and administrative framework of licensed nuclear facilities, requires notification by the Nuclear Safety Authority. The request for decommissioning, submitted after dismantling and control of the final state, is subject to various public consultations and a public enquiry, like for the final shutdown. For decommissioning, the enquiry covers any easements to be set up, use restrictions or precautionary measures, radiological measurements in the worked down area, for example.
In terms of the end state, the Safety Authority is requiring for complete clean-up of the facility's civil engineering structures, a major step in the total and unconditional release of the site.

THE NUCLEAR ENERGY DIVISION CHOICES IN TERMS OF DISMANTLING

The main ideas

The Nuclear Energy Division dismantling plan ensures the end of cycle of shutdown facilities and contributes to optimum management of all experimental tools.
Given the availability of funds required for the dismantling operations and past experience, which has validated the techniques for future dismantling, the CEA's Nuclear Energy Division has adopted the following principles for its future dismantling of facilities or part facilities.

To reduce the risk levels as quickly as possible and make the most of the experience of operating teams, radioactive clean-up is launched without delay once production is finally shut down. Immediate dismantling is normally chosen after this clean-up work to avoid loss of information on facility construction and operating conditions, as well as to avoid the extra expense from extended monitoring of the facility and maintaining its current condition. For optimised management of waste generated by these dismantling operations, new interim storage facilities have been or will be constructed at the Marcoule and Cadarache centres. This policy is supported by optimised management of all transport containers and packaging, resulting in some cases in the construction of new equipment.

Delayed dismantling can be an option if the gain from the decay of short-lived radionuclides (simplified dismantling operations and reduced waste management costs) is greater than the extra expense in extended monitoring of the facility and maintaining it in its current condition.
Delayed dismantling is also chosen when it is reasonably possible to wait for a waste evacuation outlet to open for operation - graphite, for example thus negating the need to construct new interim storage facilities.

The target final state for the facility once dismantling is complete must lead to total decommissioning of this facility for its potential re-use without restriction or monitoring or its demolition into conventional waste. The cleaned-up facility therefore no longer has a nuclear waste zone. When this objective is not achievable, interim solutions will be envisaged, for example total release with easements relating to localised hot points, with constraints and monitoring.
For the site to be released (soils and buildings) after dismantling, the calculated dose from the residual activity, under an envelope scenario, must not exceed 300 µSv/year. Further optimisation is based on miscellaneous criteria, including: cost and consequences of work (structural behaviour, dosimetry of sites, etc.) relating to the situation of the facility (CEA centre, nuclear or otherwise, public space, etc.) and its specific features (history, spectrum, etc.).

The clean-up and dismantling operations are performed according to target costs and timescales.

Protection of workers is achieved through seeking to reduce integrated doses; for protection of the environment, efforts are made to reduce the volume and level of radioactive waste and effluents generated.

Since the start, the DEN has distinguished between two major families of nuclear facilities in its dismantling plans:

- reactors (as well as accelerators and irradiators) which require preliminary calculation to assess the structures activation, and intervention simulations to prepare for dismantling which is frequently controlled remotely,
- hot laboratories, processing workshops and waste treatment facilities with the main problem relating to contamination via dry or wet processes, often associated to high irradiation levels

Assessment method for dismantling costs

The costs and financial risks of a facility dismantling project are estimated by a computing tool, , which assesses times, quantities of effluents/waste, doses and costs generated by the clean-up/dismantling operations of a nuclear facility.

At the end of life of a facility and when the methods must serve as a basis for scheduling and managing dismantling activities, the dismantling cost estimations are built up in more detail than when used to obtain the initial financial envelope. They are then normally based on a dismantling strategy, putting together a detailed scenario of operations to be carried out and an industrial dismantling schedule. They act as an operational quotation and as the start point for defining the project reference documents and establishing the expenditure schedule.

The organisation set up to perform the dismantling operations

The Nuclear Energy Division has set up a project organisation for its dismantling operations. The Nuclear Energy Division acts as the owner, project supervisor for strategic and operational project coordination, production of safety files and "nuclear operator" radiological protection assignments. The CEA normally operates the licensed nuclear facilities as nuclear plant operator. Once work has progressed to a certain extent and the nuclear risk has dropped (evacuation of nuclear materials, system clean-ups), the clean-up and dismantling operations are outsourced (to a prime contractor), unless a specific feature of a facility or special equipment requires particular CEA expertise. Except for certain traditional services, such as final demolition of civil engineering or project management support, the contracts are awarded to companies accepted by the CEA's Radioactive Clean-up Companies Acceptance Committee (CAEAR) in the fields concerned, through tenders open to all these companies.

DISMANTLING PROGRAMMES BY THE NUCLEAR ENERGY DIVISION

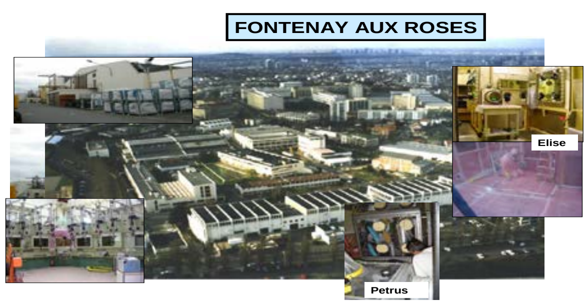
Based on principles defined above, the Nuclear Energy Division has put together a multi-annual dismantling plan covering all its nuclear facilities, regardless of whether they are already shut down or still in service.

As already stated, this dismantling plan is a component in the general Nuclear Energy Division strategy, particularly concerning the future of its research centres, namely the concentration of experimental nuclear facilities on the Cadarache and Marcoule sites, the denuclearisation of the Grenoble site and the reduction of the perimeter of nuclear facilities in Fontenay-aux-Roses. A glimpse of the plan is given below, centre by centre.

Cadarache Centre

- The ATUE, enriched uranium treatment workshops, commissioned in 1965 and shut down in 1995, will be totally dismantled shortly. These industrial-size workshops were used for the dry conversion of uranium hexafluoride into sinterable oxide, wet chemical reprocessing of fuel assembly manufacturing scrap and incineration of organic liquids. Note that the structures' contamination level was revised upwards at the end of the dismantling programme and is the object of a complementary file currently in instruction by the safety authority
- RAPSODIE is a fast neutron reactor with 40 MW_{th} power. It was shut down in 1983 and its final shutdown was pronounced in 1985. The facility's dismantling operations started in 1987 once the relevant authorisation was granted, with a view to achieving a state corresponding to former stage 2 of the IAEA. These operations were temporarily halted due to an accident (explosion) in 1994 when residual sodium in a tank was being treated. Today, the clean-up and dismantling operations have been deferred by 2030. Note that the activation of the internal reactor structures has to be reassessed.

Fontenay-aux-Roses Centre



This involves dismantling the last nuclear facilities remaining in operation on the Fontenay-aux-Roses site, the objective being total denuclearisation of the site by 2025.

- Building 18 and its annexes, built in 1954 was shut down in 1995 for the R&D section. Its role was radiochemical studies on significant quantities of plutonium from irradiated fuels and transuranic elements. The decree authorising the dismantling work was issued in 2006, fixing the end of dismantling by mid-2017. A new demand of decree will be sent to 2015 to the safety authority to extend the duration of the dismantling operations beyond 2030.

Building 18, covering about 10,000 m^2 of "hot" laboratories, houses a number of shielded lines and glove boxes. Major clean-up work has taken place since the facility was shutdown, particular on the shielded lines. A difficult site still has to be started; this involves the PETRUS shielded line where major quantities of radionuclides are still present. In addition, this line is distinct from other shielded lines due to its interconnection with a local, highly-contaminated "effluent tank" following an incident in the 1970s when the laboratory was in service.

- The RM2 facility in building 52 still has to be dismantled. In this former radio metallurgy laboratory devoted to studying plutonium-based fuels, the experimental equipment has been removed from the cells and the walls have undergone a pre-clean-up operation. The cell structure demolition is in operation, and the end of dismantling is foreseen in 2017.

- The effluent and solid waste processing station is partially dismantled. The low-level effluent treatment process was shutdown in 1994 and dismantling of the evaporator and interim effluent storage tanks is now completed; the building has been cleaned up and arranged for interim storage and waste treatment of part of the waste which will be generated during the dismantling of building 18.

The incinerator constructed in 1967 for the purpose of reducing the volume of combustible solid was finally shut down in 2000. It has now been totally dismantled.

- The decay storage facility for solid radioactive waste will remain in service until the end of dismantling operations on the Fontenay-aux-Roses site. Its dismantling will start after evacuation of 50 litre drums containing intermediate irradiating waste generated by the dismantling operations as well as those already stored temporarily in shafts. Its decommissioning is scheduled beyond 2030.

Saclay Centre

- The high-level laboratories built in 1954 and shut down in 1996 were dedicated to experiments on radionuclides. The decree authorising dismantling was published in autumn 2008. A certain number of clean-up operations have taken place under the permanent shut down reference framework. Most of the sixteen laboratories enclosing shielded cells are already empty of any process and cleaned up.

- The decree authorising the ULYSSE reactor's dismantling was published in august 2014 and first operations will begin this year.

Grenoble Centre

This involves dismantling all the nuclear facilities at the centre, culminating in total denuclearisation of the site in 2012. The first facility to have been decommissioned was the SILOETTE pool reactor with a thermal power of 100 kW_{th}: reactor operation shutdown in 2002, decree authorising the dismantling operations obtained in 2005, end of dismantling work in 2006 and decommissioning in 2007.

- MELUSINE, built in 1958, was a pond type reactor with a power that gradually increased to 8MW_{th} in 1971. It was used for material tests, basic research experiments, analyses by activation and for the production of radionuclides.

The final reactor shutdown was announced in 1993 and the decree authorising the dismantling operations was obtained in 2004. Today dismantling work on the facility is finished; the facility has been deconstructed and decommissioned after approval from the safety authorities.

- SILOE was a pond research reactor with a nominal power of 35 MW_{th}. It went critical for the first time in 1963 and was shutdown in 1997. This reactor was dedicated to material tests, the analysis of fission products generated in the fuel rods, the production of radionuclides and silicon doping.

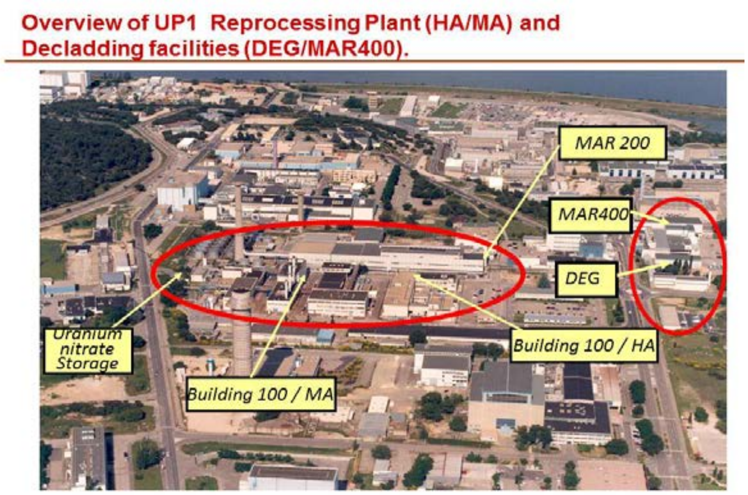
The decree authorising the dismantling operations was issued in 2005. Today, SILOE has been deconstructed and decommissioned.

- The hot laboratory LAMA, commissioned in 1961, ceased its research activities at the end of 2002. Its purpose was examinations and tests using its shielded lines to determine the laws of irradiation behaviour for fuels and materials. The LAMA received objects for examination from experimental reactors (SILOE, OSIRIS, etc.) and some power reactors (PHENIX, BUGEY, etc.). The dismantling decree has been published in 2008. End of 2012, concrete structures demolition have been performed, and today, all hot cells facility has been dismantling. Decommissioning is scheduled for early 2015.

➢ In the effluent and solid waste treatment station, commissioned in 1959, and more especially its radioactive waste decay interim storage, commissioned in 1972, only the functions useful for the dismantling of nuclear facilities on the site have been retained.

During the shutdown phase, the tanks, evaporator, incinerator, compacting press, IER (ion exchange resins) treatment, waste concreting and NaK hydrolysis units have all been shut down and dismantled.
The de-stocking of irradiating waste packages for interim storage in the Cadarache facilities should be completed in 2010.
The dismantling decree was published in September 2008. The final dismantling including demolition of buildings (lightweight construction) has been achieved and decommissioning is expected in early 2015.

Marcoule Centre



UP1 Production facilities

Major dismantling activities are currently underway on the Marcoule site, particularly the UP1 processing plant.

➢ The UP1 plant, commissioned in 1958, for reprocessing of irradiated fuels from G1, G2 and G3 reactors and extraction of the plutonium intended for deterrent. The plant's activities were extended to other customers (utilities) in 1976, in particular EDF for the reprocessing of fuels from its gas cooled reactors. At the end of 1997, after forty years in operation, the permanent shutdown of the UP1 plant was announced. Eleven facilities fall under the UP1 dismantling programme: five production facilities for fuel decladding, plutonium extraction and fission product treatment and six support facilities principally for waste treatment and conditioning. There is a wide variety of equipment to be dismantled: glove boxes, shielded lines, tanks, decladded fuel stores, conveyors, interim storage pools, pits, industrial equipment for decladding, dissolution, chemical separation, concentration, chemical conversion, vitrification, etc.

The aim is to dismantle and clean the facilities and keep the civil works in place.
The end of clean-up and dismantling operations for chemical treatment facilities is scheduled for around 2035. The first activities to be completed will be in the "intermediate-activity" part. The final activities will involve the dissolvers and evaporators in the "high-activity" part and the related tanks.

- A first dismantling state for the decladding workshops has been achieved in 2011, with redevelopment of ventilation and electrical systems to reduce the monitoring costs throughout the old waste recovery operations. Dismantling of the decladding workshops is scheduled for completion in 2033. The dismantling of the vitrification workshops and its fission product storage tanks is scheduled for after the plant. The G1 reactor, the first reactor in the natural uranium-graphite-gas system and built in 1955, was shut down in 1968. The shutdown and partial dismantling work took place between 1968 and 1987, the cell block was contained and the 110m heights stack, demolished in 2003 by using explosives. The ground surfaces released around the reactor block were reused in the 1980s to install inactive pilots and prototypes dedicated to developing fuel processing processes. These pilots are now being dismantled.
Total dismantling of the reactor will start in about 2020, i.e. when the graphite waste storage enters into service.

- The APM - Marcoule Pilot Workshop - built in 1959 was shutdown finally in 1997. It was created to confirm, at pilot scale, the correct, active operation of processes adopted or proposed for the processing plants now operated by AREVA at La Hague. 36 tonnes of irradiated fuels of miscellaneous types and origin (UNGCR, PWR, FBR, etc.) were processed between 1974 and 1997. The fission product industrial vitrification system was also developed within the APM.
The fuel processing equipment and related tanks have now been rinsed and the first dismantling has started. Note that the experience acquired from this rinsing is currently widely used for advanced rinsing of fission product storage tanks in the UP1 programme.
Work is currently in progress, radiological characterisation of cells and study of remote-controlled operation scenarios, waste evacuation, dismantling of small units and arrangements to facilitate future dismantling: access to the cells, creation of a line for fast waste output. Dismantling of this pilot workshop, a facility of more than twenty large concrete shielded cells is scheduled for completion by 2030.

➢ PHENIX is a prototype of sodium-cooled fast reactor with a nominal power of 563 MW. It was shutdown in March, 2009. The decree authorising the dismantling operations is scheduled in 2015, with 2 years delay, due to administrative processes.

Major deadlines of the project are:

- commissioning in 2018 of two facilities for treatment of sodic objects and liquid sodium treatment.
- removal of all elements of the block reactor
- end of dismantling of tanks and building’s cleaning in 2029.
- end of the defueling from the reactor,
- end of the dismantling of the reactor in 2029

SCIENTIFIC SUPPORT FOR NUCLEAR DISMANTLING IN CEA

In support to dismantling operations CEA leads R&D actions to improve safety and protection of workers, and to reduce doses, waste volume, costs and duration of dismantling operation.

CEA has been developed actions in 6 main axes:

- characterization & measuring the radioactivity (α, β, γ), of:
    - facilities
    - wastes
- work in hostile environment
- structure and soils decontamination,
- Liquid and solid waste treatment
- Methods and IT tools

Several tools have been developed at CEA:

➢ gamma and alpha cameras for mapping, are essential decision-making aid in defining scenarios for operations in a hostile environment,

➢ calculation tools to assess the activation of structures,

➢ portable system for detecting surface uranium contamination,

➢ autoradiography for beta-emitters, like tritium,

➢ LIBS, for in-situ laser measurement of species,

➢ Geostatistics method to optimize measurements and sampling,

➢ Alpha and gamma imaging, active and passive neutronic measurement,

➢ Development of robotics and virtual reality to validate intervention scenario feasibility:

▪ a remote-controlled dismantling system with force feedback (MAESTRO), with a slave arm with a 60kg at 2.30m, which should allow 60 to 80 kg/day of cut material/waste conditioned and packed in small-volume drums, i.e. more than double the capacities of current tools; this MAESTRO system will be used to dismantle the PETRUS shielded line at Fontenay-aux-Roses and in the APM cells,

The Maestro remote handling system and its carrier

- A software program simulating operations and human or robot interventions in support of the ALARA approach.

Virtual reality

- decontamination by self-drying gels , float foams or supercritical fluid, electro-decontamination, high-pressure water sprays, ice ball or carbon dioxide sprays

- laser cutting which should be used in the RAPSODIE facility and the UP1 fission products storage tanks , to improve cutting yields while limiting aerosols and waste generated

- Development of efficient treatment for complex radioactive wastes : chemical, electochemical, incineration, mineralization of organic liquids by thermal oxidation or by plasma incineration, vitrification (in-can melter), embedding with geopolymer, rinsing sequences for specific reagents (tested successfully in the APM site and used to rinse fission product storage tanks in the UP1 facility)

- Used of certified tools and methods to evaluate scenarios of dismantling : operational IT tools from cost estimation to waste and transportation management

One of the main concerns is to be able to transfer to the industry innovative technologies which could make our dismantling work safer, faster, cheaper & smarter.

LESSONS LEARNED AND INTERNATIONAL COOPERATION

One of the main lessons learned and feedback experience is that, for the CEA's facilities, which are essentially laboratories and research facilities, early dismantling, after closure, is the better solution. For reactors, waiting let the implementers get benefit from natural radioactive decrease of short lived elements, and then doses delivered to the personnel should be lower. Techniques generally improve during time and are less costly.

Today, after more than 40 years of dismantling and decommissioning work in CEA, it is generally admitted that prompt decommissioning could gain benefit from:

- the operator's experience, memory is not lost,
- surveillance and refurbishment costs should decrease,
- and the stakeholders, particularly the public could be more confident and less frightening.

Techniques and decommissioning project organization and management have evolved, personnel has highest radiological and non-radiological protection, security and safety conditions have brought some change in the situation during the period.

Furthermore, decommissioning lasted, especially for huge and complex projects, several decades, which get benefit to the natural decrease of radioactivity.
Other feedback experience has been gained on:

- Decommissioning:

To have a successful work several conditions should be fulfilled such as:

  - knowledge of the facility's radiological mapping,
  - work and tasks organization,
  - well adapted techniques should met ALARA principles (as low as reasonably achievable) and optimized waste generation,

- Operating:

Feedback experience shows that it is absolutely/really necessary to clean up periodically all along his lifetime the facility, especially when spot contamination occurs during operation.

At this prospect, to have in the future easier and more effective decommissioning, it is necessary to keep in new design for future building of new facilities the experience gained on past decommissioning projects:

- At the design stage:

Design should take into account systematically decommissioning constraints: easy accesses, remote material, lifting resources, non-porous material (to avoid contamination trapping), viewing (by using cameras or lead shielding windows), and avoid built blind cells without accesses.

- For the next future decommissioning operation:

Education and training are essential, decommissioning is a profession and implementers, staff and workers, are to be experienced.

CEA is participating to several international programmes in decommissioning as:

- the OECD/NEA/CPD (Cooperative program on decommissioning),
- the European Commission,
- and the IAEA with the IDN (International Decommissioning Network)

as well as dedicated bilateral agreement in DD&R with other interested countries (UK, USA, Japan, Russia, China, ….).

CONCLUSION

A special feature of dismantling operations at the CEA comes from the diversity of facilities to be dismantled, which are predominantly research facilities and therefore have no series advantage. There is tremendous operating feedback, however. For more than twenty years in all its centres, the CEA has acquired experience and know-how through dismantling research reactors or critical models and laboratories or plants.

The dismantling techniques are nowadays operational, but certain specific developments are necessary to reduce the doses integrated by operators, the cost of operations and to minimize delay and waste volume. Thanks to availability of techniques and guarantees of dismantling programme financing now from three-year agreement signed with French government,, close to € 11,000M for the next thirty years, for current or projected dismantling operations, the CEA’s Nuclear Energy Division has been able to develop, when necessary, its immediate dismantling strategy. Currently, more than twenty facilities are being dismantled by the CEA's Nuclear Energy Division operational units with industrial partners. Thus the next decade will see completion of the dismantling and radioactive clean-up of the Grenoble site and we pursue the dismantling of the facilities on the Fontenay-aux-Roses site. By 2030, the dismantling of the UP1 plant at Marcoule, one of the largest dismantling works in the world, will be well advanced, with most of the process equipment dismantled.