ABSTRACT

Since 2000 AREVA has carried out several projects in the field of the D&D of nuclear power plants of various types, in Germany and France. In Germany, the main topics were related to the dismantling of both the Reactor Pressurized Vessel (RPV) and the RPV internals of the Würgassen Nuclear Power Plant (NPP, BWR type), as well as the dismantling of the RPV internals of the NPP Stade (PWR type).

These projects were successful performed following highest standards in safety and delivery.

In France, the current phases of the Fast Breeder Reactor ‘Superphenix’ dismantling, near Lyon, are carried out through a specific partnership between AREVA and EDF, setting up an ‘integrated team’ focused on strategic and feasibility studies, then on-site operational studies and corresponding follow-ups.

A Sodium Neutralization Facility was built and operated with success. Large components, such as primary and secondary pumps, heat exchangers etc., were dismantled with particular attention to the sodium retention issue.

Current challenges are to prepare the dismantling of the shutdown plants in Germany and the next phases of Superphénix dismantling in France using experience and lessons learned, in order to optimize processes and efficiency.

Based on its successful projects in France and Germany, Areva has developed its competencies and ‘savoir-faire’ allowing offering optimized approaches and improvement performance plans for the management of the future reactor D&D projects.

INTRODUCTION

The D&D of nuclear power plants is performed in a certain order of concept phases. The execution of it is usually applied and approved separately. The long duration and the related high costs of the whole D&D process including application and approval of the activities comprise certain possibilities for optimization.
Plants under decommissioning have only limited added value for the plant owner, so it can be understood that cost optimization of those projects is of highest interest. Various aspects influencing D&D costs, such as:

- Strategy
- Site and dismantling operations
- Process and duration optimization
- Simplification of licensing approaches
- Social economical aspects

They are elaborated based on the experience AREVA gained from projects successfully performed in the field D&D of nuclear facilities and power plants.

**FEEDBACK FROM LATEST FRENCH AND GERMAN PROJECTS**

Some main projects have been performed by AREVA in the last decade, mainly dedicated to the key components of power reactors.

![Fig. 1: under water segmentation of RPV internals](image)

For the German NPP Würgassen (BWR type) the reactor pressure vessel (RPV) internals as well as the RPV have been dismantled, or the NPP Stade the RPV internals only. Aside the technology applied the main outcome of the project was:

- Amount of waste packages saved
- Fulfillment of the time schedule
- Limitation of dose application
- Zero accident at work policy
On French side, AREVA participate to the Superphénix Fast Breeder Reactor dismantling from the beginning. Operations started with the design and implementation of the Sodium Treatment Process allowing the neutralization of more than 5,000 tons of primary and secondary Sodium and producing around 38,000 blocks of concrete blocks to be stored on site (operations will be completed before mid-2014).

All main primary components were also dismantled (1,400 tons of Stainless steel) and specific robotics solution was developed in order to be introduced in the reactor volume for cutting sodium retention puddles assessed in certain pipes: the challenge is to comply with combination of complex geometry and hostile environment. Lessons learnt cover notably:

- Plasma arc cutting on complex shapes and thick plates,
- Ventilation,
- Optimization of design to facilitate operators works

These operations were achieved successfully and carried out in the expected schedule. Specific lesson learnt of this project is the powerful effect of the ‘integrated team’ principle that we implemented between EDF (owner) and AREVA teams, both On-Site and in Back-Office. This allowed sharing of experiences and reactivity while costs and schedule of the project remained under control despite numerous hazards which affect any dismantling program.
Fig. 3: Superphenix – large components dismantling

Learning’s derived from these projects are various. As the key learning’s are dedicated mainly to process optimizations in order to improve performance and safe costs, they are easy to translate from fuel cycle plant D&D projects to reactor D&D and vice versa.

COST OPTIMIZATION POTENTIAL

The cost drivers for D&D projects are various if the question is raised which of them can significantly be influenced two areas are of main interest.

The strategy is without any doubt the key element to determine the dismantling costs. Various – often very local – influences have to be evaluated in different scenarios in order to define the optimal strategy for a project in a given legal and political environment.

Beside this, site management and operations over the long period of project performance are vital to be optimized costs. Operation cost will mostly be influenced by the overall time frame and the reduction of unnecessary operating systems. D&D costs are strongly driven by project planning/management and the efficiency of project execution.

A performance improvement plan summarizing all those aspects shall be in place at the very beginning of a D&D project in order to set targets and follow them over the project live time.
PROJECT STRUCTURE PLANNING AND FORCED D&D PHASES

Two of the key roles in setting up a successful D&D project are the decision for a certain business model inside the project structure and the order of distinctive project phases before reaching the licensing process.

The decision for the best applicable business model includes questions like how much responsibility should be delegated and which interfaces affect the success of the project most. Therefore, different business models are possible for the project execution: from subcontracting of several different project parts to different contractors, even with engineering and project management in the customer’s responsibility to the convenient turn-key solution by one experienced contractor including the licensing process.

However contracting of large packages will reduce significantly efforts on interfaces. It will also generate opportunities for savings and synergies between sub-projects, for example logistics, resource management, common use of machinery and infrastructure. Based on this model the projects will be accelerated and the timeline will be reduced.
The optimized order of project phases is very important for the licensing process and the work performed on site later on. A very time and cost efficient philosophy concerning the order of D&D phases is to reduce the radioactive inventory (nuclear steam supplying system, NSSS) as fast as possible. Any further phases will be simplified by health and safety efforts, shielding and protection as well as requirements regarding licensing. At this stage most activities can be based on industrial/conventional decommissioning standard.

STRATEGY FOR LICENSING AND PLANNING

Licensing in the nuclear business takes more time than in other businesses due to complicated regulations and the necessity of approval by different instances of official channels. Hence, a slim and aim-oriented licensing process should be the start into a successful, time and cost optimized D&D project. Therefore, it is highly recommended to perform a feasibility study and an overall decommissioning plan prior to the licensing process, to figure out the best way to perform the D&D project. This makes clear wording of the licensing documents easy, without unintended exclusions of options which could be needed for the best possible on site performance. For a clear picture of the radiological inventory of the primary circuit components it is very helpful to do detailed sampling as early as possible after the end of operation and full system decontamination. Sampling will also help performing segmentation and packing plans as accurate as possible later in the project planning phase.

DEFINITION OF WORK PACKAGES BASED ON RADIOLOGICAL AND LOGISTICAL ASPECTS

As a first step it is important to reduce significantly the radiological inventory by removing the fuel. This was done in previous D&D projects in nuclear power plants. The next highly recommended step is the further reduction of the remaining radioactive inventory by a chemical Full System Decontamination (FSD). It cannot only reduce the dose rate for all future work on the primary circuit components including their segmentation, packaging and transport. It can also reduce the personnel’s work times and personal protection equipment (PPE) requirements
to be protected against radiation. Moreover, the FSD can lower the radiological classification of waste segments in order to classify them for waste containers for lower radioactive material.

Afterwards, the decommissioning should be started. According to the principle “from hot to cold”, the primary circuit components (NSSS) should be dismantled to reduce the radioactive inventory as soon as possible. One big advantage of doing so in the very beginning of the D&D activities is that the plant’s logistics and transport facilities are fully operational at this time. The same situation applies to decontamination and waste treatment equipment as much as to the plant’s remaining operational systems. After the removal of the primary circuit components almost the whole radioactive inventory of the plant is removed in a very early state of the project.

**Fig. 6: Strategy “from hot to cold”**

In numbers it means – even not talking about fuel removal – only two measures, full system decontamination and dismantling of the reactor internals can lower the activity content – and so the hazardous potential of the plant – by a Factor of 100 Million.

In this stage the base is given to substitute the operational systems by mobile systems. Within this activity the operational systems can be significantly simplified (e.g. ventilation ducts and under- inflation areas).

Now the “conventional” decommissioning of buildings and concrete structures can take place without permanent interfaces to the important “hot” decommissioning work.
The personnel’s knowledge and experience gained during operation of the plant is very valuable for the D&D planning and performance. This includes important aspects, e.g., knowledge about handling plant equipment, logistics and transport equipment on site. Furthermore, nobody knows the components with all its details better than the plant’s operation team. If this know-how is used for the project planning and execution, it can significantly reduce the performance duration and raise the planning accuracy of the overall D&D project. An incentive model based on fulfillment of milestones will help to keep motivation and initiative of the plant staff. Additional motivation could be gained by showing the plant personnel a long term perspective by establishing of a decommissioning expert pool. Those experts, bundled in an institution with a long term commitment towards nuclear technology and decommissioning, would guarantee the collection of lessons learned and the establishment of a continuous improvement process over a period far beyond a single projects live time.

AREVA’s well developed, proven D&D concept for segmentation and packing, together operational experience of the plant’s personnel will ensure a successful project. To implement all conceptual know-how into an efficient D&D project, the collaboration between customer and AREVA should start as early as with the licensing process.

CONCLUSION

D&D projects – as large projects generally - are influenced by a variety of different topics. Strategy and planning are very demanding as they are defining the costs of the project for a long period of time. Addressing the political and legal framework are keys for D&D projects as final disposal concepts usually are handled by governmental organizations.

If the conditions as described are fulfilled, i.e. contractor and customer collaborate already during the licensing process and the project starts with a fast minimization of the radiological inventory, the overall project duration will be reduced. Again, this offers an enormous potential to save costs. Moreover, remaining operational systems can be reduced much earlier and
replaced by mobile operating systems due to the loss of radioactive inventory. AREVA additionally contributes to these benefits by offering inclusive work packages that minimize interfaces and optimize synergy effects. Obviously some technical aspects are truly demanding but to care for an optimization of the social-economical framework appears to be challenging at least in the same way.