DESMANTELAMIENTO

MITIGATING RISKS IN NUCLEAR REACTOR DECOMMISSIONING

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Nuclear reactor decommissioning is an activity subject to significant cost variations, due to a degree of uncertainty in several domains. Orano has been delivering decommissioning programs for over thirty years on a number of facilities, in different countries, and has thus integrated the return on experience allowing to anticipate, eliminate or mitigate risks on current reactor and fuel cycle decommissioning projects.

INTRODUCTION

The decommissioning of nuclear facilities, power reactors, research facilities or fuel cycle plants, started over thirty years ago. However, as of today, the number of facilities which have been entirely dismantled and brought to green field is rather limited. According to many, only Ten power reactors have been brought to greenfield so far.

In addition to economic considerations, the significant level of uncertainty and risk involved in decommissioning can explain the relatively low number of projects entirely completed so far.

With more around fourty years of decommissioning experience as a nuclear operator first, and as decommissioning services provider, Orano has learned to identify, anticipate and mitigate the risks associated with decommissioning.

A SIGNIFICANT VARIABILITY

International organizations such as the International Atomic Energy Agency (IAEA) or the Nuclear energy agency (NEA) have been collecting and compiling decommissioning cost and schedule records from nuclear facilities operators around the world.

Furthermore, thanks to regulatory obligations, nuclear operators are required to provide budget and schedule forecasts for their future decommissioning programs. Such figures are published in a variety of formats and can be difficult to interpret.

However, the International Structure for Decommissioning Costing (ISDC) published by the NEA [1] the provides a standardized format and methodology to present decommissioning costs and allow comparisons.

Figure 1 below illustrates the result of extracting decommissioning cost forecasts from a number of countries, while figure 2 shows the average weight of each ISDC component in the global cost of a decommissioning program.

Figure 1 strikingly shows that the actual and expected budgets of decommissioning nuclear reactors vary very significantly from one country to another, but can have a great variability within countries as well if one considers the United States, Japan and France.

The average budget of around five hundred million euros is bounded by a lower value of around three hundred million euros and a higher figure of more than a billion euros.

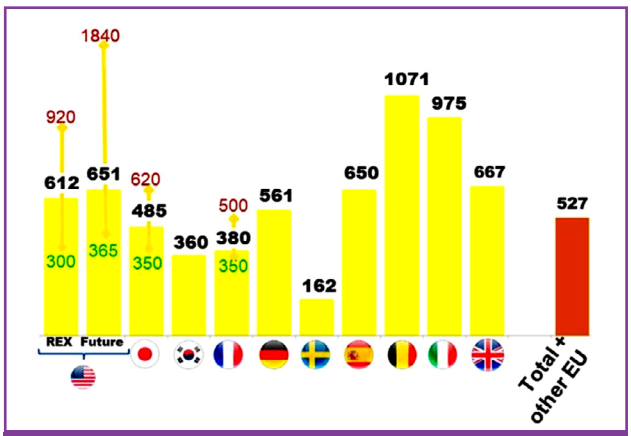

Figure 1. NPP decommissioning budgets by country.

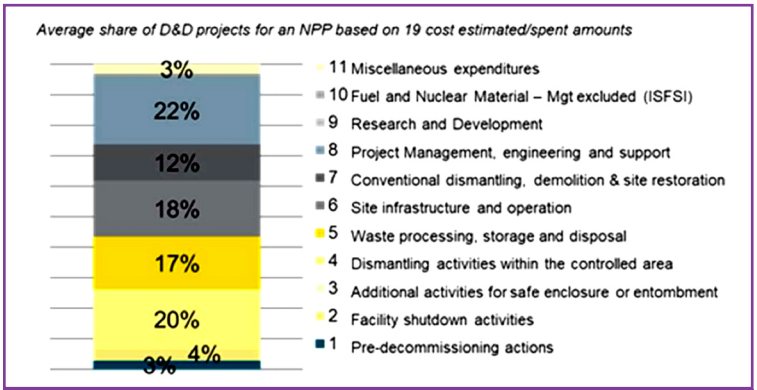

Figure 2. Average share of budget of each ISDC cost category.

Figure 2 provides an additional element of information by indicating that the overall decommissioning costs are spread over a number of items which are very different in nature from one another.

SCHEDULE & BUDGET RISKS COVER A WIDE RANGE OF AREAS

The analysis of our past decommissioning experiences as well as the records from other past decommissioning operations indicate a number of areas of factors which are most commonly subject to contingencies in decommissioning programs.

They are listed below:

- Strategy & planning are determining factors. A wrong basis will cost for years
- Managing the transition from operations to decommissioning
- Adequate knowledge of the initial state is the foundation
- Proper management of regulatory & safety aspects is key
- Spent fuel retrieval and storage has a major impact
- A robust & efficient waste strategy ensures a smooth program
- D&D projects are staff consuming: ~40% of the total expenses
- Reactor Internals & pressure vessel segmentation are the most technically challenging stages.

Quite interestingly, these areas tend to match or approach the ISDC cost categories, and show that decommissioning risks and contingencies cover the whole spectrum of each program.

SUCCESSFUL STRATEGY BASED ON ORANO DECOMMISSIONING EXPERIENCE

Orano currently has a large portfolio of decommissioning projects, in France on the fuel cycle and research area, in Germany and the United States most notably in the power reactor decommissioning sector.

These projects are the continuation of a decommissioning activity which started in the late 80s early 90s for Orano, both as a site owner operator, and a service provider for reactors.

Continued decommissioning activity for more than three decades has allowed us to build a significant body of experience which we now apply on our projects to reduce the occurrence of project contingencies and improve performance.

The following three projects are illustrations of the operational deployment of the experience accumulated over years.

Brunsbüttel reactor, Hamburg, Germany

The Brunsbüttel nuclear power plant is a 771 MW boiling water reactor, owned in majority by Vattenfall. It was shutdown in 2011 for immediate decommissioning.

Orano as leader of a consortium together with the packaging company EWN was awarded the contract for the segmentation and packaging of core waste, as well as the reactor pressure vessel internals, which represents around two hundred tons of low level to intermediate level waste.

The scope of work includes the work package planning, documentation, tools & equipment procurement, engineering, project management as well as site execution.

One important customer driver is the minimization of waste containers in general, and more specifically for Intermediate waste containers which are very costly both to supply, and to manage during several decades of interim storage on site as currently planned.

Another important customer driver is the minimization of collective dose which has been achieved by providing a segmentation concept mainly based on under water cutting.

Of course delivering on schedule and within budget remain the pillars of customer priorities.

The key success factors of this project regarding our scope of work are listed below:

An Integrated Approach in the segmentation planning and licensing Strategy is necessary, involving all actors and stakeholders. Complex In-containment operations require the full collaboration and interfacing of a number of actors, and the viability of the entire operation is based on this smooth interaction. Feasibility studies and investigations help underpin the overall concept.

Modelization and sampling of the reactor pressure vessel and its internals are key elements both as the basis for waste package minimization, work safety and operational dose reduction. Our proprietary activation modelization software has been deployed and tuned on a number of projects which ensures the accuracy of the models and allows to limit the number of samples required to adjust the model.

Segmentation of the vessel internals and the vessel are the most complex work package of a decommissioning program. Indeed decommissioning cost estimators generally allow for significant provisions for contingencies on this part of the job, compared to other activities.

The deployment and efficient use of underwater segmentation solutions for reactor vessels internals are not straightforward activities, as “lessons learned” literature shows.

Our broad experience has allowed us to develop and qualify solutions which are now deployed on an industrial basis on

several projects. They combine efficient cutting tools (such as Water Abrasive Suspension cutting), with reliable carriers, an underwater robot, and water purification systems to avoid work stoppages due to lack of visibility.

However, tools alone are not sufficient to ensure smooth delivery, and we thus train operators, whether they are from Orano or partners, under inactive conditions, prior to deploying the equipment on site. We also dispatch supervisors on our current operations to ensure smooth delivery and control the safety of operations.

Finally, our scope of work is strongly interfaced with the customer's structures and organizations for waste management and interim storage. Indeed, part of the success of the segmentation operations relies on the timely availability of adequate containers, the availability of the reactor crane, the provision of sufficient space in the working area, and the timely evacuation of containers from the workface.

The provision of a robust waste management process, together with interim storage facility, greatly facilitates delivery.

Vermont Yankee, United States

With a dozen reactors shut down, the North American market offers significant potential for dismantling activities. Private generating companies approach Orano thanks to its expertise in providing comprehensive dismantling services.

In February 2017, Orano and American demolition specialists NorthStar created a new joint decommissioning company called Accelerated Decommissioning Partners (ADP), which planned to acquire the complete and permanent ownership of decommissioning assets including the spent nuclear fuel. ADP aims to provide a turnkey final decommissioning solution to the initial operator and provide technological, regulatory and financial solutions in order to reduce project time spans and costs.

Thanks to this expertise, in 2017, Orano won the contract to dismantle the reactor vessel and internals of the Vermont Yankee nuclear reactor as the subcontractor of NorthStar.

ADP also introduces new tools for the reactor's internal segmentation while at the same time transferring the spent fuel using innovative dry storage technology (Orano NUHOMS®). ADP unique technology also includes remotely operated underwater tools to segment the reactor parts and so improve waste package loading to comply with the regulatory requirements for transport and removal from the site.

This contract benefits from leveraging the experience acquired by Orano at Maine Yankee, Rancho Seco, Millstone-1, Connecticut Yankee, Yankee Rowe and SONGS-1, to optimize project management.

The value proposition of the ADP offering is that the decommissioning fund, liability and delivery responsibilities are transferred from operators to companies whose expertise is decommissioning.

The success of such operations thus requires the proper preparation and elimination or reduction of project risks in a number of areas, identified previously:

- Acceleration of spent fuel retrieval to reduce spent fuel pool operating expenses, and creation of associated Interim storage pad or facility

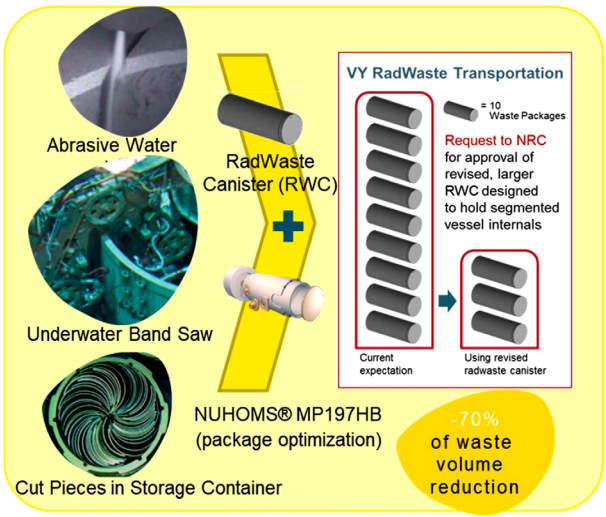

Figure 3. Waste package optimization delivered on the VY project.

- Waste Management Planning with the creation of industrial waste management facilities, storage and disposal routes
- Design and Licensing of optimized radwaste containers to minimize the quantity and volume of waste packages generated.
- Plant modifications to transition from operations to decommissioning plant configuration and reduce the operating expenses and decommissioning constraints.
- Professional management of regulatory requirements for licensing and site release
- Proven and efficient segmentation tools and processes for reactor pressure vessel and internals
- Industrial demolition competences to minimize the overall schedule.

Figure 3 illustrates how the combination of an efficient segmentation concept combined with well selected and carefully optimized packages allowed for a significant reduction in the total number of packages needed for the program.

Orano La Hague First reprocessing plant: UP2 400

The Orano (former COGEMA) reprocessing plant UP 2400, located on the site of la Hague, combines all the challenges that can be faced on a fuel cycle or nuclear research site. At the time of final shutdown in 2003, it encompassed several buildings corresponding to the various stages of spent fuel reprocessing as well as laboratories, effluent treatment facilities, legacy process waste silos, capacities or pools and a significant inventory of legacy operational waste.

Figure 4 illustrates the site layout and perimeter. Colored buildings are those included within the decommissioning program while the grey ones correspond to buildings belonging to the still operating reprocessing plants on the site of la Hague.

UP2 400 is Orano's largest decommissioning endeavor so far, with a budget of over 4 billion euros, a total schedule of about thirty years, six million working hours of work and over fifty thousand cubic meters of waste to be produced, conditioned and evacuated during the period.

The program is currently at around 30% of total work progress, and the majority of operations are focused on the most active, and main process equipment in the facilities.

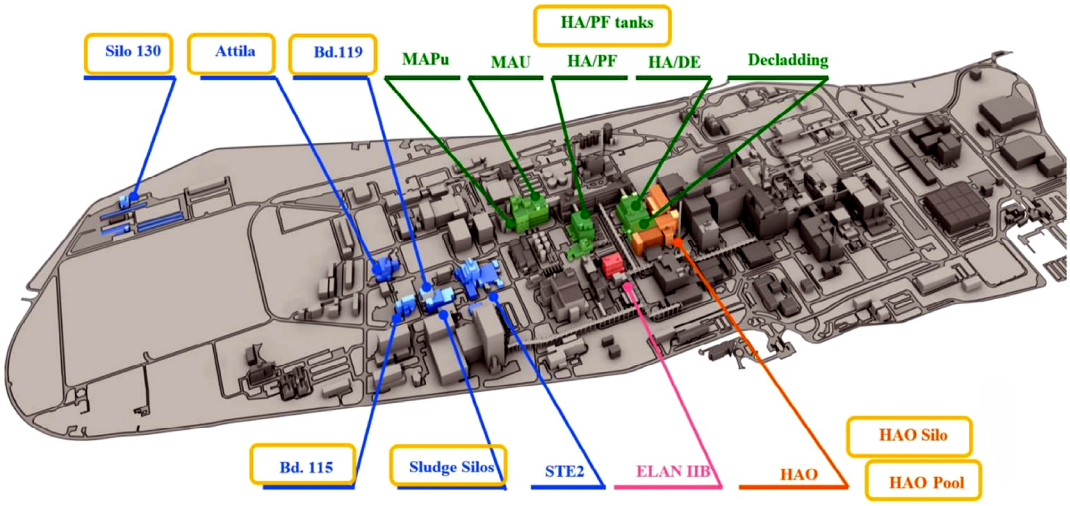

Figure 4. La Hague decommissioning perimeter.

More than Five hundred Orano staff are engaged in the project, from program management, to study, facility operation and maintenance, or delivery.

This program is benefiting from the experience of previous dismantling operations on other sites, and offers a testing ground for innovations and further performance improvement initiatives.

One of the first lessons learned integrated into the program has been the deployment of a comprehensive characterization program to secure and underpin the psot operation cleanout and dismantling operations.

A full time team of twelve to fifteen people has been deployed for several years to investigate all potential risky cells and locations, sample residual liquids or solids, and provide a clear view of the plant status. Such a program has allowd to divide by about three (3), the level of contingencies on the program.

Secondly, a comprehensive waste management strategy was established at the onset of the program, with the creation of decommissioning specific waste routes and packaging solutions, a dedicated waste management specialists team of over twenty people, and the creation of waste treatment and interim storage facilities. This has allowed to ensure that waste issues did not interrupt decommissioning delivery.

Thirdly, although the majority of dismantling operations are done by hands on activities, a small number of operations require remote operation and robotics. Following past experience, all such operations equipment and processes are first qualified using scale one mock-ups, to ensure smooth delivery once in active environment.

Fourthly, such a long decommissioning program leaves many opportunities for innovation and performance improvement during operations. However, past experiences have shown that innovation, if not properly focused on achieving gains in productivity and delivery, can actually generate costs with insufficient return. Our innovations are targeted for deployment on site and are measured against the savings they will generate over the duration of the program.

Lastly, the transition from plant operation to decommissioning has generated a major cultural shift within the former Orano plant operators, and necessitated a complete change of organization from the previous models. Once again experience from previous projects allowed us to smooth and shorten the organizational and cultural transition, as well as allowing a significant portion of the former staff to embark effectively on the decommissioning program.

This further helped secure key competences and retain important plant knowledge within the new organization.

CONCLUSION

Despite several decades of existence, reactor decommissioning remains an activity presenting a number of risks and uncertainties, in several areas of each endeavor.

More than thirty years of decommissioning experience have provided Orano and its partners a significant return on experience, allowing to continuously deliver dismantling gprojects, for fuel cycle and reactors alike, with visible progress.

REFERENCES

[1]. OECD Nuclear Energy Agency, International Atomic Energy Agency, European Commission (2012), International Structure for Decommissioning Costing of Nuclear Installations, ISBN 978-92-64-99173-6, OECD/NEA, Paris.