Waste Management Strategy for Dismantling Waste to Reduce Costs for Power Plant Decommissioning – 13543

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ABSTRACT

Decommissioning of nuclear power plants generates large volumes of radioactive or potentially radioactive waste. The proper management of the dismantling waste plays an important role for the time needed for the dismantling phase and thus is critical to the decommissioning cost.

An efficient and thorough process for inventorying, characterization and categorization of the waste provides a sound basis for the planning process. As part of comprehensive decommissioning studies for Nordic NPPs, Westinghouse has developed the decommissioning inventories that have been used for estimations of the duration of specific work packages and the corresponding costs. As part of creating the design basis for a national repository for decommissioning waste, the total production of different categories of waste packages has also been predicted. Studsvik has developed a risk based concept for categorization and handling of the generated waste using six different categories with a span from extremely small risk for radiological contamination to high level waste. The two companies have recently joined their skills in the area of decommissioning on selected market in a consortium named ndcon to further strengthen the proposed process.

Depending on the risk for radiological contamination or the radiological properties and other properties of importance for waste management, treatment routes are proposed with well-defined and proven methods for on-site or off-site treatment, activity determination and conditioning. The system is based on a graded approach philosophy aiming for high confidence and sustainability, aiming for re-use and recycling where found applicable.

The objective is to establish a process where all dismantled material has a pre-determined treatment route. These routes should through measurements, categorization, treatment, conditioning, intermediate storage and final disposal be designed to provide a steady, un-disturbed flow of material to avoid interruptions. Bottle-necks in the process causes increased space requirements and will have negative impact on the project schedule, which increases not only the cost but also the dose exposure to personnel. For these reasons it is critical to create a process that transfers material into conditioned waste ready for disposal as quickly as possible.

To a certain extent the decommissioning program should be led by the waste management process.

With the objective to reduce time for handling of dismantled material at site and to efficiently and environmental-friendly use waste management methods (clearance for re-use followed by clearance for recycling), the costs for the plant decommissioning could be reduced as well as time needed for performing the decommissioning project. Also, risks for delays would be reduced with a well-defined handling scheme which limits surprises. Delays are a major cost driver for decommissioning projects.

INTRODUCTION

The number of NPPs in Western Europe that is subject to decommissioning has increased since the Fukushima accident. Some countries have taken political decisions for phase out of nuclear power, which will increase the need for decommissioning competence and probable D&D projects running in parallel. This could lead to shortage of competent staff, techniques, and facilities for handling radioactive waste from decommissioning. There is need for development of the decommissioning process in order to minimize the economic consequences for facility owners and the community. A smooth and environmental friendly decommissioning process is also important to prove that nuclear energy is a sustainable energy source i.e. a platform for nuclear new build.

LESSONS LEARNED FROM D&D PROJECTS

Since D&D projects have been performed for a few decades, there are lessons to be learned from the previous D&D projects in which the companies within ndcon have participated in.

- Plan for an early start – Plant knowledge will disappear over time.
- Implement waste led decommissioning.
    - Waste is about 1/3 of total cost.
- Characterize based on clear objectives.
    - The information needed for project performance as well as for clearance, waste processing and disposal requirements must be well known from the beginning of a D&D project.
- A well-structured categorization is the basis for graded approach in clearance.
    - Huge amounts of waste, potentially contaminated but, most likely subject to clearance is to be handled within the decommissioning project.
- Rip-pack-ship concept for off-site waste treatment of contaminated waste will reduce project calendar time.

- The project calendar time has a major impact on the total cost for the decommissioning project. Significant costs can be spent on reduction of project time aiming for reduction of total cost.
- Dedicated waste treatment facilities can easier ensure that proper techniques and equipment are available as well as staffing with required competence and experience to manage large scale waste treatment and conditioning projects.
- In many cases no need to build advanced on-site waste management facilities if off-site treatment facilities exist. Off-site facilities reduce the work for the decommissioning organization, are available during the entire decommissioning program and will not be a decommissioning burden for the NPP decommissioning project.

WASTE MANAGEMENT AS PART OF THE D&D STEPS

There are several steps in a typical D&D project, see Fig.1, and waste management is an important part of most of the steps.

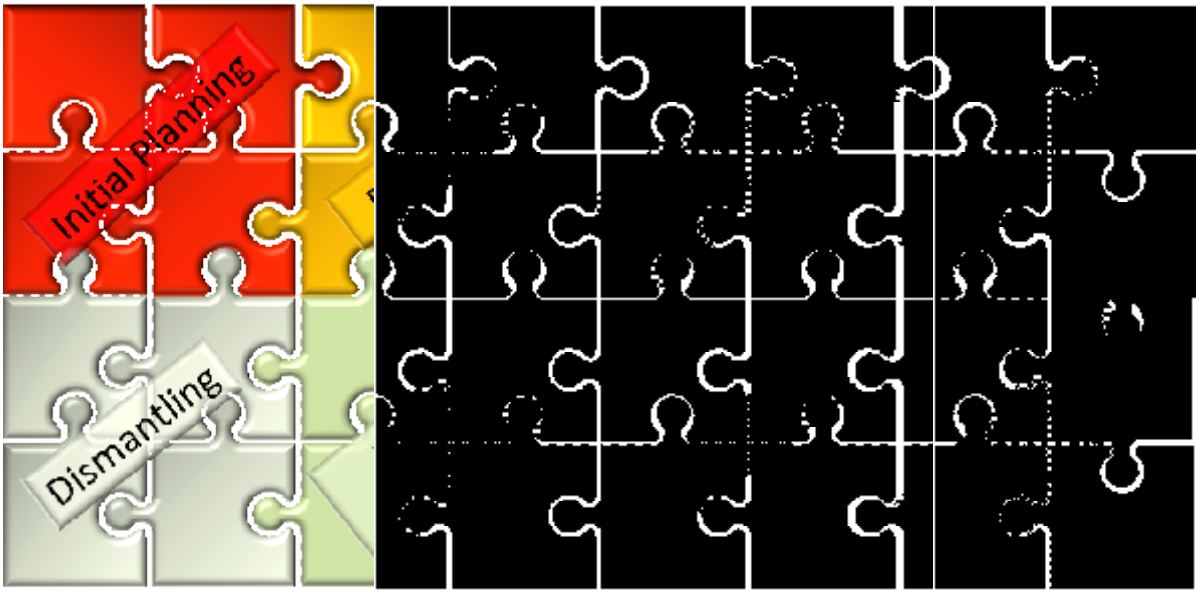

Fig. 1. Typical steps in a D&D project.

Initial Planning

The initial planning is a crucial step for a successful D&D project, and includes

- Development of the decommissioning strategy

- Define shortest possible time schedule including which actions to be made to secure the realization
- Which resources are needed when and how to secure the availability
- Initial radiological characterization
- Waste management
  - Decision on what shall be done locally respectively off site
  - Plan for implementation of a risk based graded approach
  - Secure exits for all waste streams
- Risk identification, evaluation and implementation of compensatory actions.

Earlier work [1-3] has established the foundation for the planning; a typical example is shown in Fig. 2. The applicable Swedish regulatory framework for D&D projects [4-11] has recently been partly adjusted to better harmonize between existing national Swedish and international frameworks (IAEA, OECD/NEA, EC and others). The ndcon concept [12] for D&D projects is well adapted to the regulatory framework and in line with its intension of recycling and minimizing radwaste disposal volumes.

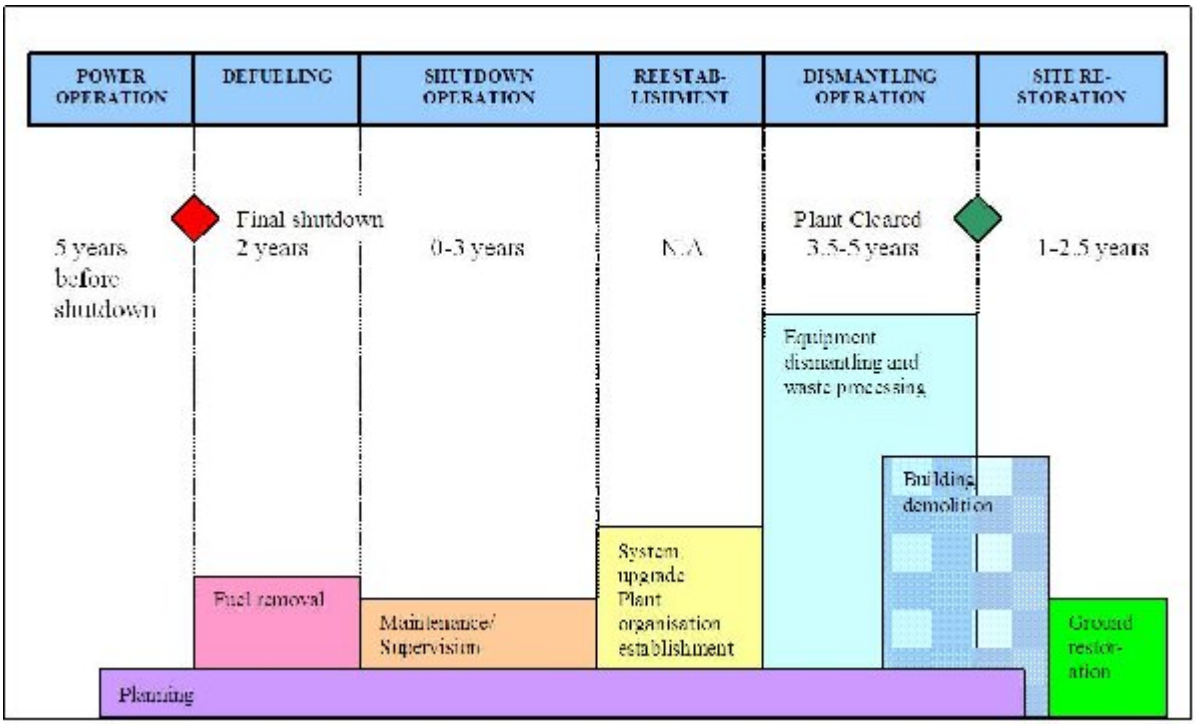

Fig. 2. Typical time schedule for a D&D project.

Inventory and Characterization

Recent development and performed projects [13-16] have indicated that fast, safe and cost effective inventory and characterization can be achieved. A reliable inventory and characterization is crucial for a useful prediction of materials, volumes, time schedule and resources. Important tools for the analysis of the characterization data are 3D modeling of the plant and the possibility to perform simulation of the waste streams [17]. Other related topics are

- Based upon characterization results, develop dose budget
- Identification of historical activities, incidents, modernizations and changes, unknown spillages, undefined waste streams.
- Definition of data quality objectives
  - For what will the characterisation results be used
- Management of the samples and gathered results
  - Database with a structure to fulfill the needs of the different D&D phases
  - Archiving strategy for samples
  - QA and record keeping
- Knowledge management

It is important to consider that a more precise characterization can have a major impact on dose to workers and/or cost. Of this reason is the definition of the data quality objectives crucial.

From previous studies [1-2] the following inventory was estimated.

TABLE 1. Radioactive waste inventory for a typical Swedish BWR.

Activity Category	Specific Activity [Bq/g]*	Inventory [tonne]	
		Metal	Concrete
Non Contaminated	~ 0	6 000	70 000
Very Low Low	0-1	16 000	170 000**
Low Low	1-20	1000	2000
Low Medium	20-100	700	300
Low High	100-1000	600	300
High	> 1000	2 100	400

*) Gamma emitting nuclides (Co-60 mainly)

**) Surface contamination dominating on wall surfaces.

Decontamination

Decontamination is usually needed of different reasons such as to reduce dose to staff and to optimize further waste treatment and to meet clearance/release criteria. The decontamination types that will be applied

- Full system decontamination for dose reduction
- Decontamination in situ / local workshop
- Building decontamination / scrubbing of painted surfaces or shaving of concrete
- Decontamination in off-site radwaste treatment facility to meet clearance or disposal conditions.

Dismantling

The dismantling procedure is suggested to be developed in close co-operation with the NPP operator, and is proposed to be organized system by system in room by room [18, 19]. Rip and ship is a time saving method to allow transports off-site for further waste handling with minimum on-site requirements for temporary buffer storage. Routines for re-characterization of waste needs to be robust in order not to cause delays and logistical problems in the case that waste needs to be re-characterized, re-checked or re-evaluated. Preparation for the clearance process (including characterization and decontamination steps as necessary) of rooms and buildings can start when all systems, installations and waste have been removed [18].

Waste Treatment

Off-site waste treatment in for example the Studsvik facilities is using well proven techniques to achieve high percentage of recycling and disposal volume minimization [21]. The off-site treatment portfolio covers several waste stream categories such as

- Metals including large components for decontamination and/or melting
- Soft waste/DAW for incineration
- Wet waste (oils, ion exchange resins, decontamination liquids etc.) for thermal treatment
- Nonmetallic inorganic scrap for decontamination and clearance alternatively volume reduction.

The nuclide information to be obtained by sampling and radiometric analyses after waste treatment depends largely on the quality and acceptance of the nuclide vectors provided by the NPPs [22] as

well on the tracking of the entire handling of the waste. Also the knowledge about how the nuclide composition is affected in the waste processing is of importance. All together it must be ensured that adequate and relevant information is recorded in the waste treatment phase for the further conditioning, intermediate storage and disposal of the waste.

Demolition

Once the clearance of the buildings has been performed and approved by the authorities, the conventional demolition of the buildings can take place.

Waste Disposal

WAC for disposal and related requirements may differ depending on the waste category (ILW, LLW, and VLLW); one example is given in [23]. Waste that can be conditioned directly for disposal should be segmented according to an object specific waste management plan considering all steps in the handling process including how to optimize the loading into the disposal containers.

With a well performed planning covering and considering the WAC, a careful selection of disposal containers, a tailor-made packing plan the disposal volume can be reduced significantly and by then the cost. An example how to achieve a high packing density is shown below, see Fig. 3.

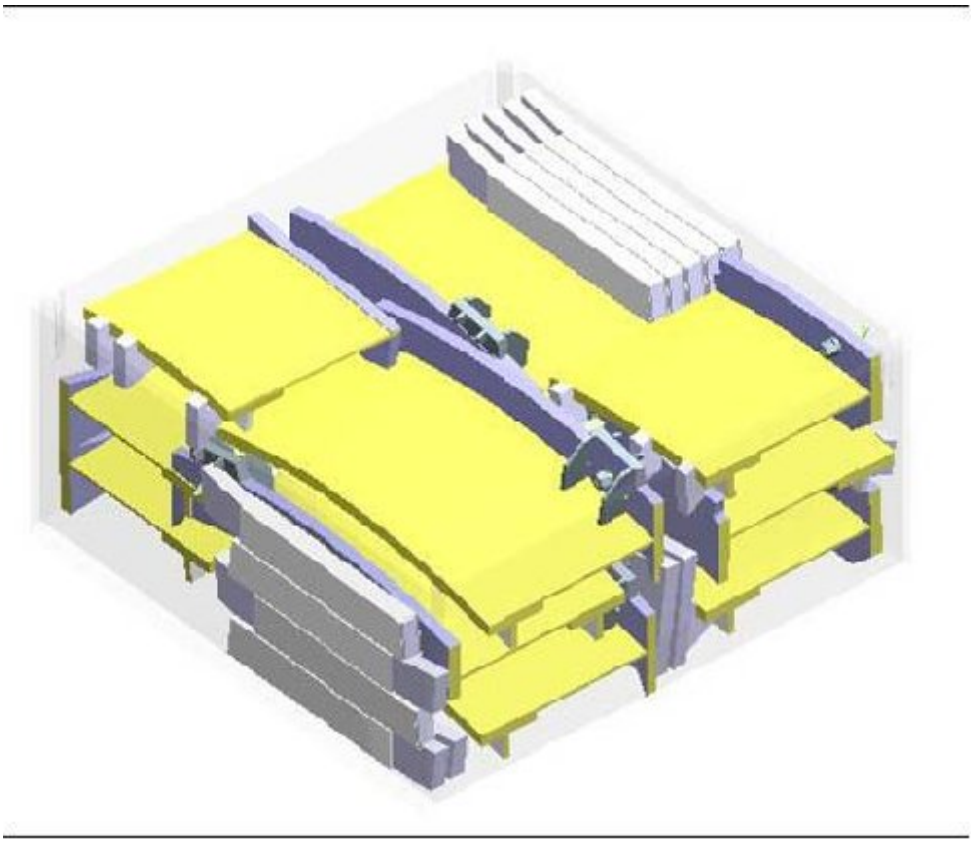

Fig. 3. Waste, in this case parts from reactor core internals, conditioned directly for disposal based on a segmentation and packing plan to achieve a high packing density in line with the WAC for disposal.

RIP & SHIP

The Rip & Ship concept (i.e., rip, pack and ship) for waste removal from the D&D site has several advantages which will help transition of site status.

- Minimize calendar time for decommissioning (decreased cost)
- Remove waste early in the process to allow the startup of the later phase of the decontamination process as early as possible
- ”Transform” the nuclear site to a more standard industrial demolition site (easy access and operation, Increased safety)
- Maximize volume reduction and recycling (best in class environmentally, reduced final disposal)

- Ensure optimized packaging of waste sent off site
- Possibilities to obtain good conditions for clearance measurements of material to be released on site.

Two types of transports will be dominant:

- In ISO freight containers (mainly loaded with boxes)
- Large components (wrapped or with the component itself as package)

Three major transport alternatives are considered:

- Ship
- Truck
- Train

The selection and combination of these alternatives will be site specific considering logistics, environmental and cost parameters.

THE NDCON WASTE MANAGEMENT CONCEPT

Based on the previous experience, the existing regulatory framework, disposal requirements, and the NPP owners' expectation for safe, fast, and cost effective decommissioning, the ndcon waste management concept has been developed. The waste management concept is described in Fig. 4. Variants may be applied to consider local conditions. A first analysis is proposed to be performed in an early phase indicating the logistics and treatment alternatives for the waste streams, see Fig. 5. This analysis can be rather complex and could benefit from the use of a simulation tool.

The waste management is using a concept based on risk for contamination and activity level class to optimize the treatment. For the lowest categories (extremely low risk, and low risk) the actions needed can take place on-site. For the remaining categories (risk / VLLW, LLW, and ILW), the actions needed (waste treatment) are in most cases proposed to be handled off-site. For the off-site waste treatment, different facilites are used depending on the waste streams. The Decontamination and Free Release facility can be used for waste streams not suited for melting, such as cable, galvanized steel, motors, and, electronics. Melting is proposed for carbon and stainless steel, copper, aluminium, nickel base alloys, brass, and lead. Incineration is used for burnable waste and will result in a stable end product sutiable for disposal. The simulation tool is also used to identify bottle necks and to optimise the needed space and equipment.

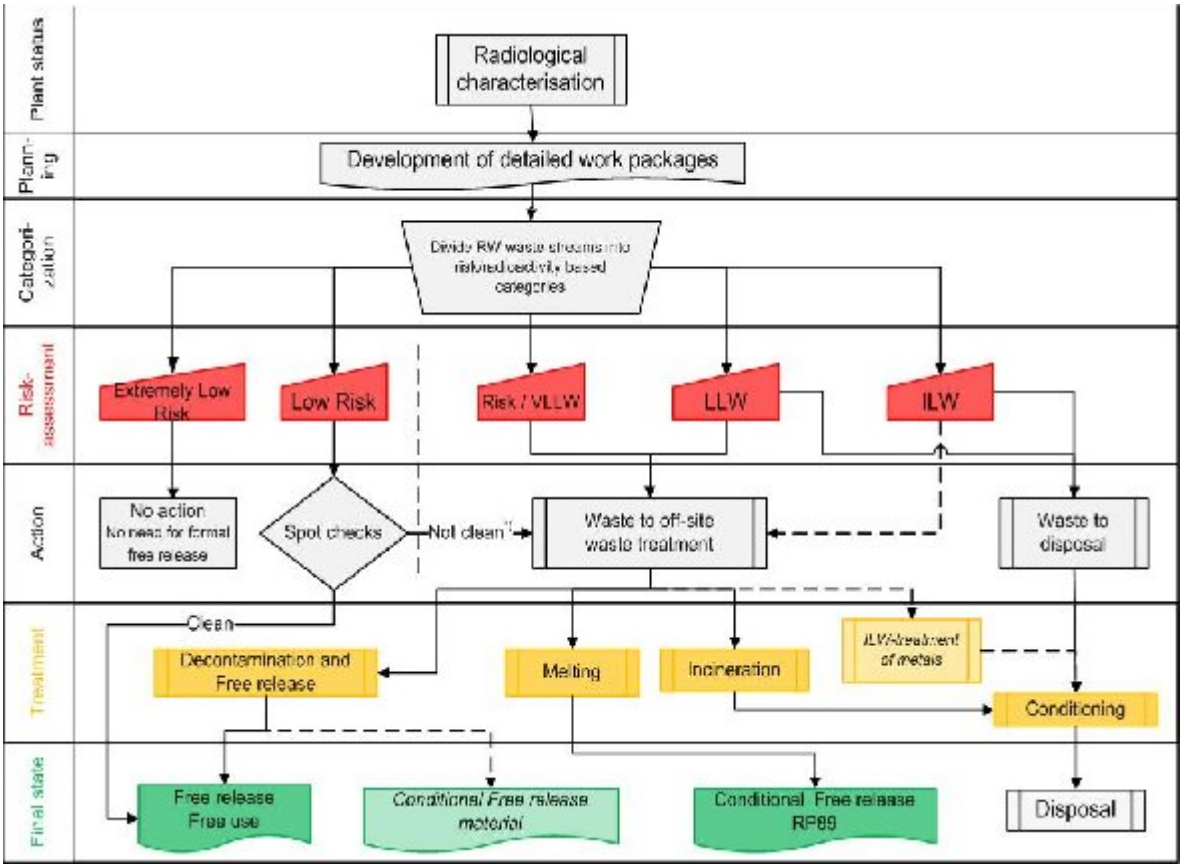

Fig. 4. Risk-based concept for waste management during decommissioning.

The need for ILW-treatment of metals depends on local national disposal conditions, off site treatment can shorten the on-site decommissioning time and increase packing efficiency and optimize the disposal by separation between short-lived and long-lived waste.

The disposal volume for a typical BWR can, according to performed studies, with the ndcon waste management concept be reduced by up to 2/3, leading to substantial potenital savings for the NPP owner.

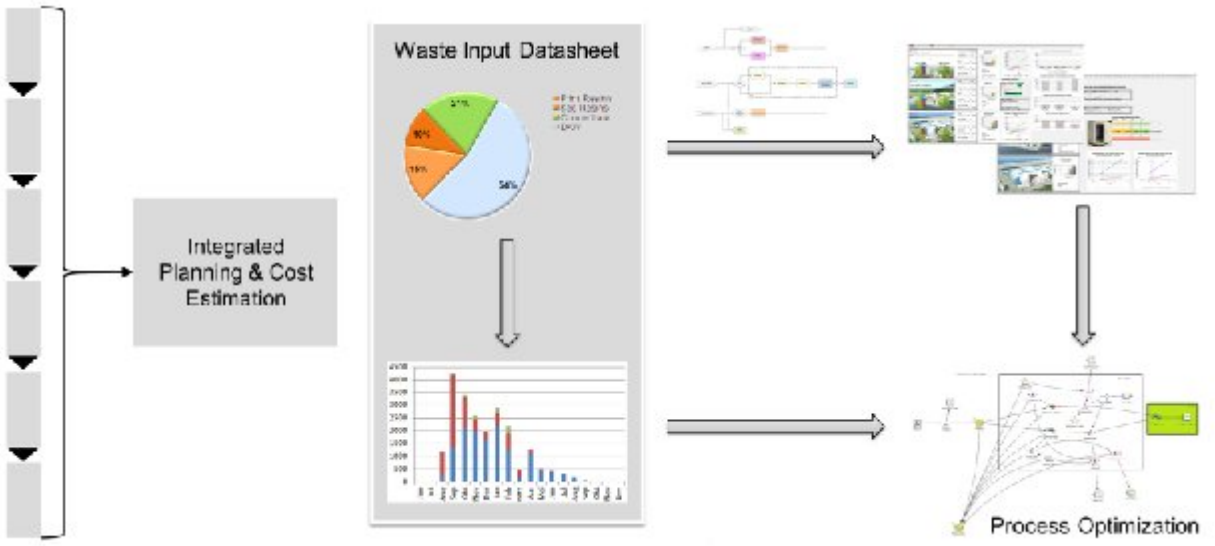

Fig. 5. The simulation tool is used to analyse waste streams, identify bottle necks and to optimise the needed space and equipment for the D&D project.

CONCLUSIONS

A concept for safe, fast, cost effective and environmentally sound management of decommissioning waste is proposed to cover

- Risk based waste stream categorization
- Rip and ship waste management with minimum storage on-site
- Focus on material re-cycling and waste minimization for disposal
- Industrialized proven processes
- Dedicated off-site facilities with buffer capacities for the waste storage and treatment
- Close co-operation between all involved parties to optimize the entire waste management process
- Intense planning involving waste management treatment and disposal facilities
- Minimize the project calendar time and focus on a start as early as possible (considering both ALARA perspectives and plant knowledge parameters).

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[1] In Swedish.