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Compilation of End-User Requirements for Site Characterization

Authors : Mr. Jeremy BUTTIN (EDF) Jérémy Buttin (EDF); Sylvain Janski (EDF)

INSIDER - Contract Number: 755554
Improved Nuclear SIte characterization for waste minimization in DD operations under constrained EnviRonment

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Summary

The aim of the document is, based on a survey performed among the members of the End Users Group (EUG), to provide to the INSIDER project with an overview of ongoing decommissioning projects within EUG members states, their applicable regulations related to Decommissioning and Dismantling (D&D) operations, and their practices regarding characterization process. In addition to the information gathered, their main difficulties are highlighted listed, and will help the INSIDER project to focus on potential End Users requirements.

Approval

Date	By
2017-11-21 11:11:32	Mrs. Paolo PEERANI (EC-JRC)
2017-11-22 13:58:26	Mrs. Danielle ROUDIL (CEA)

INSIDER

Improved Nuclear SIte characterization for waste minimization in D&D operations under constrained EnviRonment

Research and Innovation action
NFRP-2016-2017-1

WP2 – Task 2.1 End users requirements for initial characterisations of contaminated sites and structures in constrained environment

COMPILATION OF END-USERS REQUIREMENTS

V0

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Information

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1. Aim of the document – Methodology

The aim of the document is, based on a survey performed among the members of the End Users Group (EUG), to provide to the INSIDER project with an overview of ongoing decommissioning projects within EUG members states, their applicable regulations related to Decommissioning and Dismantling (D&D) operations, and their practices regarding characterization process. In addition to the information gathered, their main difficulties are highlighted listed, and will help the INSIDER project to focus on potential End Users requirements.

A questionnaire has been drawn up in collaboration with the leaders of work package 2 and task 2.2 and sent to the End Users Group members. The following synthesis report is based on the answers to the survey.

Nine end users, from 7 different countries returned the questionnaire filled:

- EnergoRisk Ltd, Ukraine
- ENRESA, Spain
- SCK CEN - Belgian Nuclear Research Centre, Belgium
- European Commission – Joint Research Centre (JRC), Italy
- Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF), Japan
- Brenk Systemplanung GmbH, Germany
- Kraftanlagen Heidelberg GmbH, Germany
- Electricité de France (EDF), France
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), France

Three different levels of confidentiality were proposed to the participants of the survey:

1. "Fine to publish the whole questionnaire with name"
2. "Fine to publish the whole questionnaire anonymously"
3. "Just use the answers as part of a general overview / statistical analysis"

This report is made in accordance to the wishes of each participant regarding the confidentiality level of their answers.

Those only who are in the first category have been fully reproduced in the Appendix 2 of the present report.

The answers that are classified in the second category are whether directly used or summarize in this report without mention to the participant.

For the others, information have been summarize as part of the following sections so the confidentiality of the answers is fully respected.

When relevant and possible (enough category one or two data available), a country by country approach has been chosen to provide a more accurate view on the processes specific to each EUG country.

2. Overall decommissioning program within EUG members' countries

The table hereafter summarized transmitted information regarding the ongoing decommissioning projects within the participants' countries. This information is then detailed, country by country, in section 2.1 to 2.6.

Reactor Type	Number	Power range [MWe]	Fuel	Coolant	Moderator
Pressurized Water Reactors	19	40-1300	enriched U, MOX	water	water
Boiling Water reactors	19	260-1000	enriched U, MOX	water	graphite, water
Gas-Cooled Reactors	11	15-600	natural U, enriched U, Th	CO2, He	Graphite
Light water reactors	see PWR line				
Fast Breeder Reactors	2	21-1240	natural U + Pu, enriched U	Na	-
Heavy Water Reactors	3	57-165	natural U, enriched U, MOX	Light water, D_2O	D_2O
Accelerator based and sub-critical facility	2				
Research Reactors	>16	0 - 44	UO2, Metal, Alloy	light water, heavy water,	light water, heavy water
Other: shelter unit 4 Chernobyl NPP	1	1000	fuel carrying masses	water	-

Table 1 : List of ongoing D&D projects in End Users countries

All types of reactors are represented. The facilities under a decommissioning program are not limited to commercial or research reactors: in addition, fuel cycle related facilities, waste management and storage facilities and other research facilities (see example of France, section 2.1) are also undergoing D&D projects around Europe.

2.1. Situation in France

A complete list and description regarding all the nuclear power plants and nuclear facilities that are currently part of a decommissioning program in France can be found on the French National Safety Authority website[1].

The names and locations of these Nuclear reactors and facilities are summarized by the following figure.

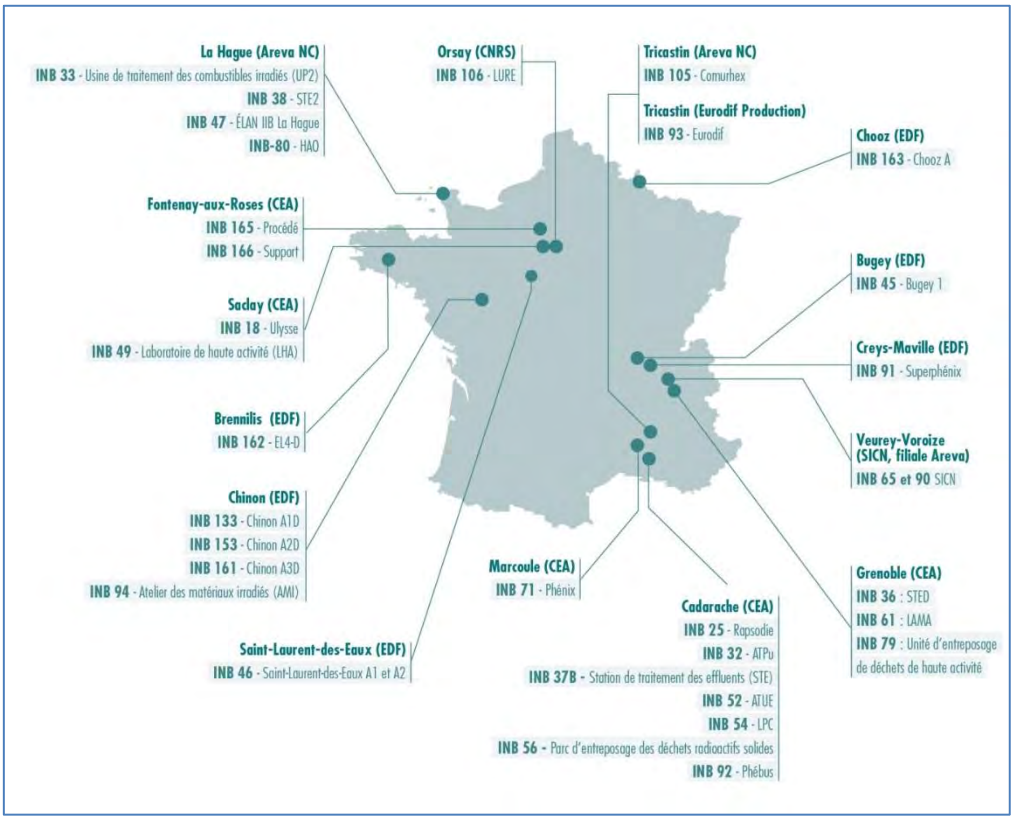

Figure 1 : Map of ongoing D&D projects in France

The table hereafter provide information regarding the first generation of reactors that have been build and used by EDF to produce electricity for commercial purpose.

[1] https://www.asn.fr/Informer/Dossiers-pedagogiques/Le-demantelement-des-installations-nucleaires/Les-installations-en-cours-de-demantelement

Reactor type	Number	Power range (MWe)	Fuel	Coolant	Moderator
Pressurized water reactors	1	300	enriched U	water	water
Gas-cooled reactors	6	70 to 540	natural U	CO2	graphite
Light water reactors	1	300	enriched U	water	water
Fast breeder reactors	1	1240	natural U + Pu	Na	-
Heavy water reactors	1	70	natural U	CO2	heavy water

Table 2 : List of decommissioned commercial reactors in France

Other facilities, mainly owned by the CEA and Areva, are whether related to fuel cycle production and treatment, or research reactors and facilities.

2.2. Situation in Japan

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurised water reactors	3	340-559	UO2	Light Water	Light Water
Boiling water reactors	8	357-840	UO2	Light Water	Light Water
Gas-cooled reactors	1	166	UO2	CO2	Graphite
Heavy water reactors	1 (ATR)	165	UO2-MOX	Light Water	Heavy Water
Research reactor	10	0.0002-36	UO2, Metal, Alloy	Light Water Heavy Water	Light Water Heavy Water

Table 3 : List of ongoing D&D projects in Japan

2.3. Situation in Belgium

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurized water reactors	1	40	Various types of nuclear fuel have been tested (MOX, high burn-up, etc.)	Water	Water

Table 4 : List of ongoing D&D projects in Belgium

2.4. Situation in Germany

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurized water reactors	6	672 to 1302	Uranium 235/ Mox	water	water
Boiling water reactors	5	260 to 926	Uranium 235/ Mox	water	water
Gas-cooled reactors High temperature Pebble bed reactor	2	15 (prototype) and 308	Thorium 232 / Uranium 233	Helium	graphite
Light water reactors VVER (pressurized water of Russian type)	6	70 to 440	Uranium 235	water	water
Fast breeder reactors (research)	1	21	Uranium 238	Sodium	
Heavy water reactors (research)	1	57	Uranium (natural)	D_2O	D_2O
Research reactor	6	1 to 44			

Table 5 : List of ongoing D&D projects in Germany

Two more Boiling Water Reactors and two Pressurized Water Reactors are applying for licence since a few years.

In addition to these reactors, two facilities are currently undergoing a decommissioning program:

- A vitrification facility (VEK- Reprocessing pilot plant)
- The Siemens Power Generation in Karlstein (Hot cell research facility, middle-active Lab (MAL), analytics, (temporarily) waste incineration (AREK), waste water treatment (AWEK))

2.5. Situation in Spain

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurised water reactors	1	160	UO2	Water	Water
Boiling water reactors	1	500	UO2	Water	Water
Gas-cooled reactors	1	500	Natural Uranium	CO2	Graphite
Research reactor	1				

Table 6 : List of ongoing D&D projects in Spain

2.6. Situation in Italy

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurised water reactors	1	600	UO2 (low enriched)	Water	Water
Boiling water reactors	2	900	UO2 (low enriched)	Water	Water
Gas-cooled reactors	1	600	Natural U	CO2	Graphite
Research reactor	several	<25			

Table 7 : List of ongoing D&D projects in Italy

2.7. Situation in Ukraine

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Boiling water reactors	3	3×1000 (electric power)	Uranium oxide	Water	Graphite
Accelerator based and sub-critical facility	1				
Others : Object “Shelter” Unit #4 of Chernobyl NPP	1	1000 (electric power)	the fuel-carrying masses	Water	

Tableau 8 : List of ongoing D&D projects in Ukraine

In addition to the reactors listed above, the Storage of Spent Fuel (SSF-1) and of solid radioactive waste (HTO-1), both located on the Chernobyl NPP site are undergoing a decommissioning process. More information regarding these two facilities are available in Appendix 2.1.

3. Regulatory frameworks and licensing processes

The regulatory framework is specific to each country, which makes difficult any generalization at a European or International level.

Though in some countries the choice is given to facility owners, most use an "immediate" dismantling approach after preparatory activities, often imposed by law. Obtaining the permission to decommission may take several years depending on national rules, licensing process and project complexity, availability of waste packaging, transport, storage and disposal solutions.

For most of the participants, the main target of decommissioning and remediation is to reach the release of the site (green field). However for some facility owners, the release of existing building and plants for other industrial uses (within nuclear industry or not) is an option.

Depending on the country, the regulatory body can be seen as whether pragmatic and collaborative, or tied by public acceptance issues and / or to a direct application of the law, that makes discussion difficult.

In any case, getting a license is an essential precondition to start any D&D activities. To obtain such a license, all the operators have to submit a decommissioning plan, which implies a sufficient knowledge of the facility and the operations to come.

A country by country approach is developed in the following sections to provide more detailed information.

3.1. Situation in France

In France, the dismantling of the civil nuclear plants is managed by a set of laws, orders, decrees, by the French national Safety Authority (ASN) decisions and ASN guides:

1. The National Programme Act n°2006-739 of 28 june 2006 on the Sustainable Management of Radioactive Materials and Waste
2. ASN guide n°6, related to the decommissioning and dismantling of nuclear facilities
3. ASN guide n°14, related to the cleaning of structures in nuclear facilities
4. ASN guide n°24, related to the management of polluted soils in nuclear facilities

For a given plant, a specific decree covers all dismantling operations. To cease permanently operation on his installation and to obtain such a decree, the operator of the nuclear facility must inform the French government and the ASN.

A decommissioning safety report is written by the operator and studied for approval by the ASN. This first report must be issued no less than three years before the planned date for final shutdown. Then, no less than one year before final shutdown, the operator must submit to the government (and the ASN) a final shutdown and dismantling application.

This document should then at least be updated every 10 years. It defines the dismantling strategy, to optimize the interventions and finally to launch environmental impact studies (both during normal and accidental circumstances).

In France, the evaluation of the application is subject to the same procedure as for the creation of a new facility, and the provisions concerning modifications to the INB during the course of operations are also applicable to modifications of a facility during the course of the final shutdown or dismantling process.

3.2. Situation in Japan

In Japan, D&D activities for normal operating reactors are ruled by the Reactor Regulation Act. This law may also be applicable to accident reactors.

The regulator involved is the Nuclear Regulation Authority (NRA), who reviews the D&D plans submitted by the operators. Such a review typically takes one year. Immediate dismantling is not part of the Japanese regulation; however, the funding system for D&D activities implies immediate dismantling. NRA is also supported by R&D activities performed by the Japanese Atomic Energy Agency.

The main target of D&D projects is the release of the site after deconstruction and remediation operations. At the end these operations, completion of D&D according to the plan submitted have to be confirmed by the NRA. Currently, standards for the completion are not determined yet.

3.3. Situation in Belgium

In Belgium, there is no specific legislation regarding D&D activities. Based on REX from the first D&D projects, the Belgian authorities (FANC & BEL V) have drafted two position papers: one position paper for the release of buildings, and another for the release of sites. However, the level of detail in relation to the initial characterization process is rather limited. Also, the Belgian legal framework does not specifically mention details regarding the strategy (e.g. immediate or deferred dismantling). Usually reference is made to IAEA defined strategies (DECON, SAFSTOR, Entombment). The aimed final end-state of a decommissioned site is the “green-field” (site release)

The authorities involved are:

- The FANC/AFCN (Federal Agency for Nuclear Control)
- The BEL V (Competent authority in the field of nuclear applications, and subsidiary of the FANC/AFCN)
- The NIRAS/ONDRAF (Belgian National Agency for Radioactive Waste and enriched Fissile Material)

The applicable legislation corpus is detailed in Appendix 2.3, and the licensing process can be summarized by the following figure. Such a process can be 1 to 2 years long.

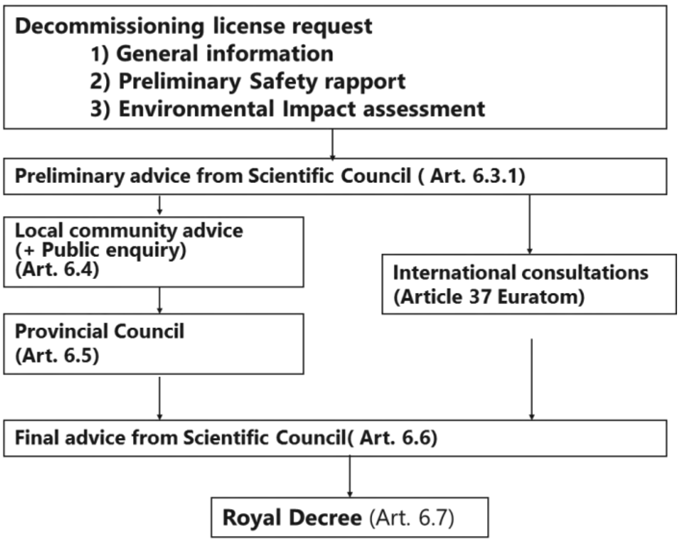

Figure 2 : Licensing process in Belgium

3.4. Situation in Germany

In Germany, the applicable set of law regarding D&D operations comprises:

- the Atomic Act (AtG),
- the Radiation Protection Ordinance (StrlSchV),
- the Publications of the German Commission on Radiological Protection and the Nuclear Waste Management Commission,
- DIN[2] standards (e.g. DIN 25457, related to waste characterization).

Both immediate dismantling and safe enclosure are admissible by law. However, immediate dismantling is the preferred way proposed and applied by the German operators. Different levels of authorities are involved in the licensing process:

- Authorities responsible for nuclear licensing and nuclear inspection (State authorities)
- Authorities responsible for radiation safety (Regional authorities)
- Authorities responsible for building licensing and inspection (local authorities)
- Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety and its sub-organisations as supervising organisation

The licensing process in Germany begins with a strategic decisions (for example immediate dismantling or safe enclosure), continues with the general application for licence for decommissioning and dismantling, followed by the submission of a safety report, an environmental assessment report and detailed technical documents.

A public hearing is organized, and independent experts evaluate the submitted report before final approval. The D&D operations are finally followed and inspected by both authorities and independent experts.

"Real life" examples of this licensing process durations are provided hereafter.

[2] Deutsche Institute für Normung : German Standardization Institute

- Neckarwestheim NPP: application for decommissioning and dismantling phase 1 in April 2013, approval in February 2017
- Biblis NPP: application for decommissioning and dismantling phase 1 in August 2012, approval in March 2017
- Isar I NPP: application for decommissioning and dismantling phase 1 in May 2012, approval in January 2017

Overall, the observed licensing process is 3 to 5 years long. The main target followed by D&D operations is to reach the “green field” end state and full release of the site.

3.5. Situation in Spain

In Spain, ENRESA is by law the national company that manages the waste and it is charge of the D&D issues for the nuclear installations in Spain. After the pre dismantling activities, the ownership of the site is transferred to ENRESA for the duration of the dismantling project. After the dismantling/Site Remediation activities, the ownership is again transferred to the former owner.

In addition to ENRESA, the regulatory body is composed of the Nuclear Safety Council (CSN), the government and environmental agencies.

According to Spanish law, the dismantling operations should take place immediately once the preparatory activities are completed. During the pre dismantling period, a D&D plan has to be submitted to the regulatory body and associated ministry, in order to obtain the owner license and to take the charge of the D&D operations. The evaluation of such a plan commonly takes 2 to 3 years.

Depending on the considered project, deconstruction and remediation activities can lead to full release of the site, or to further industrial uses.

3.6. Situation in Italy

Italian regulation is based on the implementation of all the Euratom Directives. The major nuclear act is DLgs 230 of 1995; this decree has been continuously amended in order to integrate the Euratom Directives (89/618, 90/641, 96/29, 2006/117, 2009/71, 2011/70). The implementation of Euratom Directive 2013/59 on basic safety standards is still ongoing.

The Italian authorisation for D&D activities process involves the Ministry of Economic Development as the major licensing authority, but four other ministries are involved in the process (Environment, Health, Labour and Interior), and also the regional government.

The ministries are technically supported by the regulator: I.S.P.R.A. (Istituto Superiore per la Protezione e la Ricerca Ambientale).

The licensing process is organized as follow. The initial request is submitted to MiSE (Ministry of Economic Development), which requires the opinions from the other authorities: the four ministries, the region and the regulator (ISPRA). If any of the involved authorities has comments, the request is sent back to the operator for modifications and the process restarts with resubmission from the operator. When all ministries and the region approve, MiSE sends the final version for last check to ISPRA. After final approval the license is released to the operator.

For the decommissioning of nuclear reactor, before the licensing process described above, an Environmental Impact Assessment is required to be submitted and approved by the Ministry of Environment.

The followin flow chart provides a good overview of such a process. Depending on the project complexity, the duration of this process ranges from a minimum of 6 months to more than 10 years in the case of nuclear reactors.

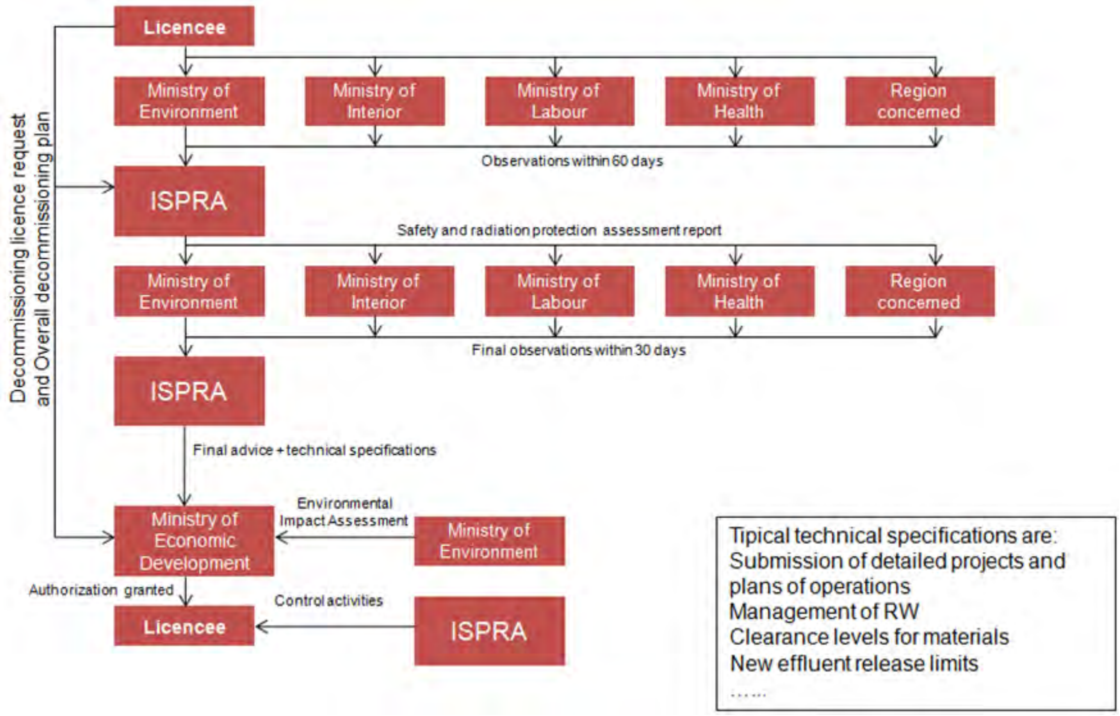

Figure 3 : Licensing process in Italy

Regarding the planning strategy, Italian reagulation leave the choice of immediate or postpone dismantling to the operator. Green filed is the preffered final state.

Regarding the The Italian law does not impose any strategy, leaving the decision to the operator. The main target for D&D activities is reaching the site release.

3.7. Situation in Ukraine

In Ukraine, any decommissioning activity has to be approved by the Ukrainian Regulatory Authority (State Nuclear Regulatory Inspectorate of Ukraine, SNRIU), who is in charge of the licensing and of implementing inspections during all stages of the process. Waste management is also subject to the state regulatory body supervision.

At all stages of decommissioning, the SNRIU implement a specific licensing. It is necessary to obtain the state license prior to begin each of these stages: cessation of operation, preliminary retention, decommissioning. Activity during the stage of cessation of operation is made in the framework of operational license, but permission is needed.

To obtain such permission the licensee should submit the following documents:

- The decommissioning plan,
- A safety Analysis Report,
- Changes in technical specifications for operation.

The main document for decommissioning activity is the decommissioning program, approved by the SNRIU. This program should include the programs for radiation protection, RAW treatment and quality assurance.

Getting the authorization to start D&D operations may take from one year to decades, depending on facility complexity, volume and activity of radioactive waste that would be generated and the availability of associated management facilities.

A complete list of Ukrainian applicable laws is provided in Appendix 2.1.

4. Objectives of the characterization process

For any respondents of the survey, the classification of the waste and the definition of proper waste management routes is the primary aim of characterization activities.

It can be achieved through:

- The determination of the nature of the radionuclides, the amount of radioactivity, and its location in the facility
- The determination of the physical state of the waste generated, and their chemical properties,
- The evaluation of the behavior of the source term within the waste generated (migration, decay…).

Preliminary characterization also allows one to choose the most effective decommissioning technology by avoiding over- or underestimation of the activity, to estimate the time needed and to predict the worker dose rates (with specific software).

It must be associated with a physical inventory in order to carry out an environmental impact assessment.

Listing specific objectives for characterization and cartography is the central goal of task 2.2, therefore they are not addressed in detail in the present report. However, since information regarding waste and soils management in EUG members' countries have been provided as part of the task 2.1 questionnaire, they are reported in the following sections.

4.1. Regarding waste management

In France

In France, the National Radioactive Waste Management Agency (ANDRA) is in charge of the long-term final management of radioactive wastes in France on an industrial scale. Three main industrial options are currently available in France:

- Disposal of Very Low Level Waste in a surface disposal facility (CSTFA Aube facility, 650 000 m3 capacity)
- Disposal of Low / Intermediate Level Waste (short-lived) in a different surface disposal facility (CSFMA Aube facility, 1 000 000 m3 capacity)
- Incineration (solids, liquids) or metlting (metals) of VLLW or LLW in the CENTRACO facility owned and operated by Socodei, a 100% EDF group subsidiary. Final waste (ashes, ingots...) are then disposed of in the proper ANDRA's surface facility

Repositories for Long-Lived waste are currently being studied. The following table provides an overview of available and future French repositories.

<table>
<tr><th>Activity - Half-life</th><th>Very short-half-life < 100 days</th><th>Short half-life ≤ 31 years</th><th>Long half-life > 31 years</th></tr>
<tr><td>Very low level waste</td><td rowspan="4">Management by radioactive decay</td><td colspan="2">Surface disposal facility (CSTFA Aube facility)</td></tr>
<tr><td>Low level waste</td><td rowspan="2">Surface disposal facility (CSFMA Aube facility)</td><td>Near-surface disposal facility being studied</td></tr>
<tr><td>Intermediate level waste</td><td>Deep disposal facility at 500 meters being studied</td></tr>
<tr><td>High level waste</td><td colspan="2">Deep disposal facility at 500 meters being studied</td></tr>
</table>

Table 9 : Available and future radioactive waste repositories in France

General waste acceptance criteria of available repositories are described in ANDRA's specifications of acceptation documents. In addition to these general specifications, each family of waste to be sent in a surface disposal has to go through a specific process to obtain the agreement of ANDRA to receive the waste packages. Getting the information required during this process are part of the characterization objectives for French operators.

In Japan

Electric power companies established Japan Nuclear Fuel Ltd. (JFNL) as a disposal company. JNFL has a LLW diposal facility that is concreat pit type at near surface. Its licensed capacity is 80,000m3. JNFL has a future plan to extend the capacity up to 600,000m3.

JAEA has a trench type diposal facility for a research reactor on its site.

In Belgium

In Belgium, there is no final disposal currently operating. A surface disposal dedicated to category A waste (short-lived waste) is in the location of Dessel. Regarding high level and/or long-lived waste, an R&D program is ongoing; however, no governmental decision has been taken at this point.

In the meantime, interim storage facilities for conditioned waste of all categories are centralised on the Dessel site operated by BELGOPROCESS, a subsidiary of NIRAS/ONDRAF, the Belgian Nuclear Waste Management Agency:

- Intermediate storage of low-level waste:
  - Building 150: capacity 1.922 m^3
  - Building 151: capacity 14.700 m^3
- Intermediate storage of medium-level and high-level waste:
  - Building 129: capacity: 250 m^3
  - Building 136: 590 containers of high-level vitrified waste and about 1.000 m^3 of medium-level cemented or compacted waste

In Germany

In Germany, there is currently no final repository in operation. Interim storage facilities ("Landessammelstelle"), licensed on the basis of the licences on base of Radiation Protection Ordinance, have been built in different location and on NPPs sites[3].

Operators with licences under the Atomic Act have to build their own interim storages. These will be taken over by the federal government in the future.

A final repository (KONRAD) for low and intermediate radioactive waste has been licensed and is under construction. The beginning of operational phase of Konrad had been delayed several times and is expected now not before 2026.

In Spain

In Spain, Very Low, Low and Intermediate Level waste are disposed of in the El Cabril disposal centre. The disposal centre is operated by ENRESA.

Regarding High Level / Long-lived waste, a centralised interim storage is being licensed. It will allow the storage of HLW during a 60 years long period.

In Italy

In Italy there is no final disposal facility. The process has been started for the localisation of a national repository site that should be able to collect all radioactive waste from all facilities in the country. The Italian repository will have two different sections: a final disposal facility for very low and low level waste, and an interim storage facility for intermediate and high level waste.

The process is idle after the preliminary study that has defined the list of potentially suitable areas. The list has not been made public yet. Once published, a public consultation will be launched in order to get spontaneous applications to host the national deposit. In negative case, the government will decide the location. The operation of the deposit is currently foreseen for 2025.

There is currently no discussion regarding a final repository for high level waste.

Up to know, waste are stored on site; the majority in temporary storage and a small part in buffer stores inside the facilities. A large Interim Storage Facility has been constructed and dimensioned to host all the waste currently available plus all those that will be produced by the decommissioning programme.

In the absence of waste acceptance criteria for final disposal, the goals for characterisation are established by a national standard, issued by the Italian normalisation body: norm UNI 11194 for characterisation of waste and UNI 11458 for clearance.

[3] A complete list of German interim storage facilities is provided at the following address : www.bfe.bund.de/EN/nwm/interim-storage/interim-storage_node.html

In Ukraine

In Ukraine, besides on site repositories, no centralized definitive repository for radioactive waste is currently operated. Numbers of interim storage facilities have been built and are located on NPPs sites or near other facilities such as research centers. A complete list of Ukrainian waste management facilities is provided in Appendix 2.1.

4.2. Regarding soil remediation

In France

As for the waste, the French regulation does not define any clearance levels for the soil. Therefore, there is no clear objective for soil remediation. The French safety authority recommends complete remediation or, if not possible according to the best available technology within an acceptable cost, a remediation leading to a level compatible with the final use intended for the site. It leads to a case by case soil characterization and remediation strategy, based on sample analysis, in situ measurements and dose mapping, and based on the results remediation operations until the determined acceptable final level is reach.

In Japan

The soil remediation strategy has not been defined yet. It is however a huge challenged that will have to be faced in the frame of the Fukushima Daiichi dismantling and remediation operations.

In Belgium

The following chart describes the soil remediation strategy which is based on the Belgian regulation.

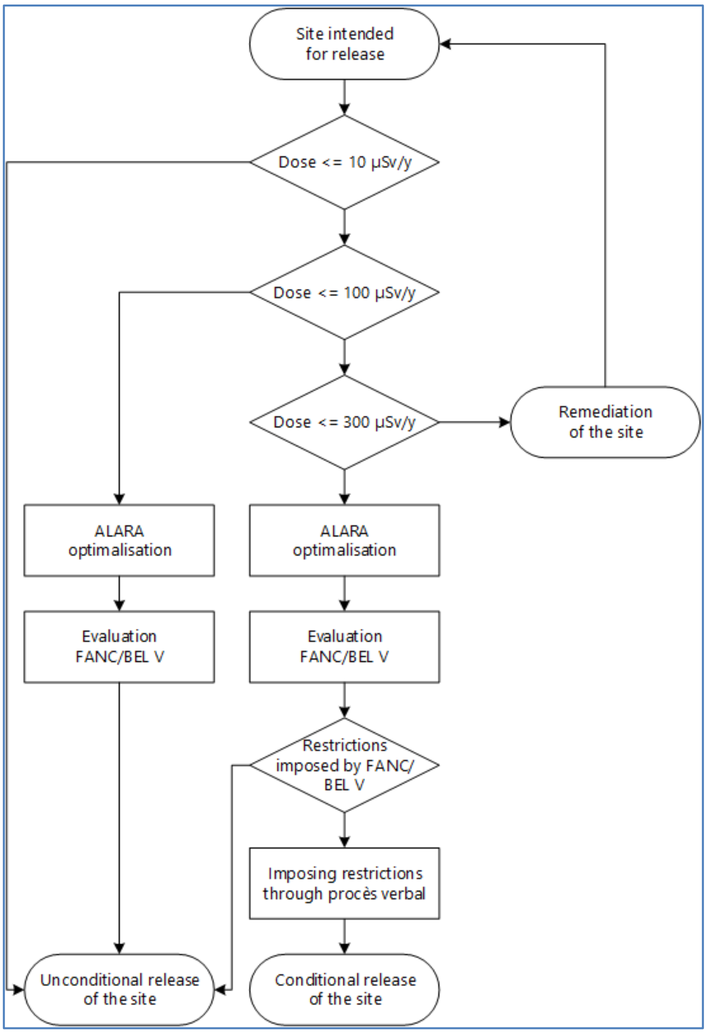

Figure 4 : Belgium soil remediation strategy flowchart

In Germany

The following methodology for soil characterization and remediation can be applied:

- Evaluation of potential contamination history,
- Screening analysis / radiological characterisation,
- Definition of areas, where clearance measurements are required (by initial classification of the area or in case of positive screening analysis results),
- Clearance measurement under the requirements of Radiation Protection Ordinance (standard 100 m² averaging, or averaging on 1 Mg of soil material ; different requirements can be defined in a single case analysis).

In Spain

In Spain, the surface and the first 15 cm of the soils are scanned and characterized, completed with boreholes campaign in order to apply statistics or geostatistics, and quantify the remediation operations that will have to be performed.

Once these operations are over, the MARSSIM (for Multi-Agency Radiation Survey and Site Investigation Manual) approach is applied with additional features (e.g. 0,5 meter depth sampling), in order to confirm the absence of residual activity.

In Italy

Up to know only a few hotspots have been detected through cartography activities, and have for most of them already been cleaned up. The resulting removed soil is currently stored on site before final disposal.

Due to the limited amount of contaminated soil detected up to now and its low level, no additional decontamination process is currently envisaged. Part of the soil might be clearable and the rest will be disposed as VLLW.

In Ukraine

Once the degree of contamination evaluated, if the soil is significantly contaminated, it can be removed and replaced by clean soil, and disposed of in surface facilities (trench type). If the contamination is below the unconditional release of the site, resettlement is possible.

5. Description of the characterization process

5.1. Overall process

The initial survey described by the EUG members is mainly based on a physical inventory, a historical assessment, calculations, in situ measurement, sampling and analysis of the results. These steps are well represented on the following figure and detailed hereafter.

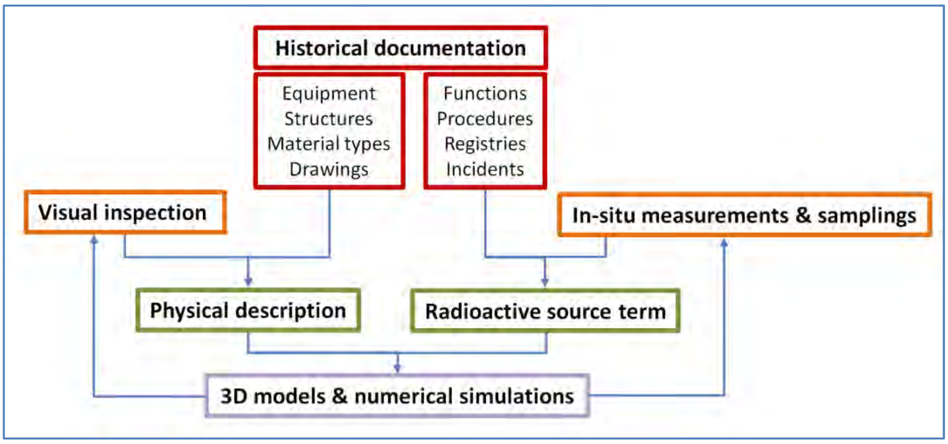

Figure 5 : General characterization process flowchart

- **Historical analysis of the facility**. All the documents produced during the operational phase of the lifecycle of the facility are gathered, archived, reviewed and analysed, in order to reconstruct the full operational records and estimate the location and typology of activation/contamination to be expected and to establish a preliminary list of nuclides. It comprises, among others, all registered data indicating the operation cycles, outage periods and other relevant aspect, such as nominal power and/or production rate, as well as details about past radiological incidents.

- **Physical inventory.** All items are listed, tagged, sometimes barcoded, and inserted in a database where also radiological info can be attached when available. This procedure requires any initial drawing available, an historic of the modifications of the facility. In most cases, to complete the exact knowledge of the nature and location of the equipments, the above physical description is complemented with visual inspection. In addition, laser scanning is often used and 3D modelling of the facility is often used.

- A sampling plan is drafted. It is followed by non-destructive **in-situ measurements and sampling** (gamma spectrometry, alpha / beta contamination, dose cartography, physical sampling of materials...). Sampling activities are all the more important in the case of contamination since, contrary to the activation, contamination cannot be properly estimated through theoretical calculations.

- All the data gathered are analyzed in order to establish correlations between hard and easy to measure radionuclides. At the end of the process, nuclides vectors (or “fingerprints”) with relative ratios between HTM radionuclides and at least one ETM radionuclide are established. In general ^{60}Co is used, but in some cases, ^{90}Sr, ^{137}Cs or ^{241}Am can also be used.

- The whole process can be consolidated by 3D modelling and numerical simulation, that are then compared and adjust with the actual values (dose cartography for instance) measured in the facility

5.2. Sampling strategy

The sampling strategy is different depending on whether considering contamination based only on measurements, contamination based on measurements coupled with a mathematical model, or activation primarily based on calculations (the measures being used to validate the approach).

Overall :

- to validate the calculated activation model, just a few measured values are needed ;
- to build a standalone measured contamination inventory around 10 measured values are needed to justify the size of the statistical population ;
- to initialize a mathematical model based on a geometric statistical approach, the number of measured values depends on the size of the surface or the volume to be characterized.

Statistical and geostatistical tools are commonly used by EUG members. Also, Pierre Gy “Sampling for analytical purposes” has been mentioned as one of the best approaches for obtaining representativeness of the sampling process, for both zero (non-structured), and one dimensional structured data.

Concerning soil remediation, different approaches can be considered, depending on the national rules, the intended use for the site, the level of the contamination, etc. Borehole campaigns can be used in order to apply geostatistical or statistical methods to quantify the remediation required.

5.3. In Situ VS Destructive analyses – cost optimization strategies

From a general point of view, laboratory measurements are more precise (i.e. lower uncertainties), allow a complete characterization (i.e. measurement of some Difficult to Measure Radionuclides – pure alpha / beta emitters), to get additional information about the chemical composition, and finally allow defining a “fingerprint” that will be used during the waste production. However, they are expensive, time consuming and require higher level of expertise and trained staff.

On the opposite, in situ measurements are often quicker and cheaper but less accurate. However, it has to be taken in account that the time needed to well interpret, with the help of numerical simulations, the results of in-situ measurements, can lead to high cost too.

In-situ measurement are thus more often use during waste production, once a robust vector has been determined through more expensive methods.

To limit the cost of necessary but expensive destructive analysis, it is to send for radiochemical analysis the lower number possible of samples, while trying to cover a wide range of values with enough activity, to be assured that values higher than Minimum Detectable Activity (MDA) will be obtained.

Other approaches are used to make as effective as possible the number of analysis performed on a given number of samples from a homogeneous zone: all the collected samples are not subject to measurement if a sufficient number of already obtain results from the same area are sufficiently close.

5.4. Evaluation of uncertainty

Uncertainty has to be evaluated in order to assess the suitability of the process carried out, and the allowed relative level of uncertainty is often a matter of discussion among agencies/owners and regulators.

As an example, in France, the overall uncertainty is included in the level of activity declared to the National Nuclear Waste Management Agency (ANDRA, who operates repositories), when a waste package is sent. These declarations have to be "reasonably overestimated" so the waste is managed properly and the safety of the repositories is insured. However, too much overestimation can lead to artificially consume the radiological capacity of the repositories or to select inappropriate and costly waste management options.

In Germany, the activity of 95% of the waste packages has to be properly declared. Only 5% of the waste packages are allowed to be maximum 1% above the declared radioactivity. Remaining uncertainties are addressed through conservative declaration, so the waste are rather over- than under-rated.

In other countries, acceptable uncertainty can evaluated based on norms, i.e in Italy using UNI-11194.

More generally, depending on the goal of the characterization:

- If there is a threshold criterion, uncertainty on the final result must be small enough to fulfil this criterion. A less precise estimation is possible if the threshold criterion is "reasonable".
- If a "best estimate" approach is used, the difficulty arises in the identification and the estimation all the uncertainty sources.

In the case of in-situ measurements, uncertainty is mainly associated to the transfer function, computed via numerical simulations, used to convert the reading value of each instrument into the actual activity of the radionuclide of interest. because of the common lack of knowledge concerning the physical description of the voluminous objects to be measured. While the associated uncertainty in destructive analysis results from both the sampling procedure and digestion process used. This latter is often necessary to provide analytical results.

5.5. Numerical tools

Numerical tools are commonly used by numbers of EUG members, at different stages of the characterization process. Those tools can be whether the result of in house developments, or commercial software for less specific applications.

- They can be related to dose rate evaluation (e.g. to predict dose rate of waste packages, or evaluate the dose rate in a specific area and thus shielding means that will have to be deployed during D&D operations), coupled or not with 3D modelling and even with dismantling scenarios simulation.

- They can be dedicated to spatial distribution of the activity and help to provide a radiological cartography of the facility (e.g. the kartotrak[4] software)
- Standards statistical tools can be used when sufficient. Geostatistical tools are also mentioned as powerful tools to improve global characterization.
- Deterministic and Monte Carlo Propagation codes can be applied to experimental data analysis, uncertainty evaluation, hypothesis tests, validation of radiological models etc.

Regarding the development of new tools / the improvement of existing ones, statistical or geostatistical software for spatial distribution of the activity, and scaling factors analysis tools have been mentioned. These softwares may have to be adapted to the goals of the characterization process, linked to the specificity of each regulatory framework.

[4] Kartotrak is a commercial GIS (Geographic Information System) that can provide mapping of contamination in a facility under dismantling.

6. Characterization process: associated challenges

Numerous challenges arise from characterization operations, and have been reported by the EUG. They are hereafter classified in different categories, including the main characterization process steps. The following sections will directly help the INSIDER project focusing on the main issues faced during D&D projects by the survey respondents.

6.1. Regulatory issues

In some countries discussions with the regulators, and the elaboration of safety dossiers that have to be produced, make the overall process heavy, especially when it comes to sampling operations in a constraints environment. Clearance processes can also be challenging in some countries.

6.2. Availability of waste disposal solutions

In the absence of a suitable waste disposal or treatment solution, it is hard for operators to define goals for a characterization plan and the associated level of uncertainty.

6.3. Historical analysis of the facility

A lot of facilities have been shut down decades ago. The staff that operates the facility is no longer available, memory and operational history may have been partially lost, making the first steps of the characterization process difficult. When available, historical documents are on paper documents, making them difficult to use efficiently.

The lack of accurate history knowledge lead to difficulties linked with heterogeneous contamination (multiplicity of different circuits), radionuclide propagation and accumulation, history of activation, and differences between predictions and measurements.

6.4. Sampling and measurements

Getting samples from every part of site can be a huge challenged, due to both radiological constraint and the lack of space in some areas (in old facilities, dismantling was not considered during the design). It is sometimes impossible to get any sample (e.g. by drilling), or only possible through the use of teleoperation, which might requires the development of dedicated tools.

It makes the collection of representative samples even more difficult. In any case, the representativeness of the sample is often mentioned as an issue by the EUG members.

Then, the samples, even collected near a hot spot, have often activies below MDA for numbers of radionuclides, making them useless to establish correlation between ETM and HTM radionuclides.

Regarding in situ measurements, the geometry of the location to be measured is also an obstacle in numerous cases. In addition, in situ measurements can result in the contamination of the measurements instruments. Again, the use of costly teleoperation means can be essential.

There is also currently a lack of high resolution spectrometric equipment and methods of measurement for alpha and beta emitters with low detection limits. Improving these equipments and methods would allow an improvement in in-situ characterization.

6.5. Radionuclides vectors

In addition to the issue associated to MDA mentioned in the previous section, three key ETM nuclides are often used to determine the HTM nuclides activity : Cs-137 for fission products, Co-60 for activation products and Am-241 for actinides. However, after more than 30 years, Co-60 has decayed significantly, and can be below the detection limits, and the low energy of gammas from Am-241 make the estimation of the activity strongly dependent from the matrix (material and density) and from the (often unknown) source geometry, introducing huge measurement uncertainties.

It has also be mentioned that for some HTM nuclides (such as 14C, 3H and 36Cl), it has been impossible to find any correlation with ETM radionuclides.

The overall consequence of the difficulty to determine robust vectors is that the operator may have to take in account too much margins, which finally have an impact on dismantling and waste management costs.

7. Need for international standards regarding characterization operations

There is no clear consensus within the members of the EUG regarding international standardization of characterization activities.

Due to the variety of facilities, of the tools, to the complexity and specificity of each regulation, it is clear that international guidelines based on good practices, that can be applied in most of the cases, is seen as more useful and easy to apply than international complete standardization which would be difficult to achieve, and is perceived as potentially too restrictive and even obstructive in some cases.

In some cases, international standards are seen as an opportunity to exchange with the national regulators, and if the standards are recognized by regulators and involve pragmatic and simpler approaches. They would also allow easier intercomparison exercises, and be beneficial in the areas of accuracy and uncertainty evaluation.

APPENDIX 1

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Questionnaire to be filled by members of the EUG

Questions numbered from 1.1 to 1.11 are directly related to task T2.1 and to the present report, whereas questions 2.1 to 2.34 are linked with task T2.2.

T2.1: End users requirements for initial characterisations of contaminated sites and structures in constrained environment

In this task, partners will conduct a review on how characterization processes are implemented by different end-users, identifying the related (prevailing) regulatory requirements and depicting the major constraints found in the process

1.1) Describe synthetically the process for a site/plant characterisation process in your country/organisation

1.2) Describe the regulatory framework for decommissioning and dismantling (D&D) activities in your country

- Applicable laws and regulations

- Did these laws preach for immediate dismantling or deferred dismantling? Please develop more about the followed strategy (waiting period, safe enclosure, entombment, etc.) in the case of deferred dismantling.

- Please specify, by clicking directly on the corresponding boxes below, the main target followed for D&D activities in your country.

☐ Deconstruction, remediation and release of the site (green field)

☐ Release of existing buildings and plants for other industrial uses

☐ Further nuclear use

- Which authorities are involved?

- How is the licensing process?

- How long it takes to get an authorisation?

- How collaborative is the regulatory body?

- Please specify the existing infrastructure for radioactive waste disposal in your country and at your sites, their status (intermediate or definitive) and their capacity?

1.3) How are defined the goals for the characterisation?

1.4) What is your strategy about the soils?

1.5) How the sampling plan is determined?

- Sampling strategy

- Balance between destructive and in-situ analyses

- Cost/benefit analysis

1.6) Which are the key points in a characterisation plan?

1.7) What is the target level of uncertainties and how are they assessed?

1.8) Which are the major difficulties/obstacles/problems that you face in characterising a plant?

1.9) Do you use software (and/or mathematical approach) to operate the results of the measures?

1.10) Do you identify tools that you would wish to have in order to improve the characterisation?

1.11) Do you see benefits from a potential homologation on international standards (to be developed) in the field of site characterisation?

T2.2: Specific objectives for characterisation and cartography

This task will establish specific objectives for characterisation and cartography and identify key parameters for decommissioning operations orientation & scenario improvement and documentation

2.1) How many nuclear power plants are currently undergoing a decommissioning programme in your country?

Reactor type	Number	Power range (MW)	Fuel	Coolant	Moderator
Pressurised water reactors					
Boiling water reactors					
Gas-cooled reactors					
Light water reactors					
Fast breeder reactors					
Heavy water reactors					
Accelerator based and sub-critical facility					
Research reactor					
Other (*please specify*):					

2.2) Please specify below, by providing as much details as possible, if there are other nuclear facilities originally planned for either spent fuel processing and recycling or radioactive waste conditioning that are currently undergoing a decommissioning programme in your country?

2.3) Please specify if there are Linac or Cyclotron installations originally planned for research or medical applications that are currently undergoing a decommissioning programme in your country? In such case, please, also give details about their primary beam current as well as their maximum energy and current.

2.4) Please give as much details as possible about the physical nature, composition estimated volume of radioactive waste and other contaminated materials (metals, liquids, plastics, concretes, soils, graphite, bitumen, etc.) commonly generated in the above decommissioning programmes.

2.5) Please give as much details as possible about specific difficulties and obstacles in the process of the decommissioning programmes.

2.6) Which are the main targets you aim to reach in:

- Radiological characterisation of an installation?

- Radiological (and/or chemical) characterisation of the soils?

- Radiological (and/or chemical) mapping of a (potentially) contaminated site?

2.7) Which are the radionuclides you look for?

2.8) Do you measure impurities (i.e. chemical compositions) to explain the level of the radionuclides measured? If “yes”, do you made sampling on irradiated or no irradiated item ? Why ?

2.9) Which protection level do you target, i.e. what activity levels and uncertainties are to be met for the key radionuclides you look for? How do you summarize remaining uncertainties and other than key nuclides?

2.10) Please specify and give as much details as possible (or provide the corresponding reference documents if any) about the measurement techniques do you apply in plant/site mapping?

2.11) Please specify and give as much details as possible (or provide the corresponding reference documents if any) about other *in-situ* measurement techniques used.

2.12) Please specify and give as much details as possible (or provide the corresponding reference documents if any) about the different laboratory analytical techniques commonly used.

2.13) Please explain (or provide the corresponding reference documents if any) the experimental procedures if any used to qualify each one of the different laboratory analytical techniques used.

2.14) Please explain (or provide the corresponding reference documents if any) the experimental procedures if any used to qualify each one of the different *in-situ* measurement techniques used.

2.15) Please explain (or provide the corresponding reference documents if any) the objectives and principle implementation of any quality assurance plan. What QA/QM guideline are to be followed.

2.16) In your opinion, what should be the specific objectives of a benchmarking exercise regarding laboratory analytical measurements?

2.17) In your opinion, what should be the specific objectives of a benchmarking exercise regarding *in-situ* measurements?

2.18) How do you correlate HTM (Hard-to-Measure) to ETM (Easy-to-Measure) nuclides?

2.19) How do you correlate HTM (Hard-to-Measure) to ETM (Easy-to-Measure) nuclides in the case of many HTM nuclides (i.e. 60Co + 137Cs for example)?

2.20) How do you manage the case with no HTM nuclide (i.e. cooling time >> 10 half-lives)?

2.21) Which are the main difficulties you encounter in defining a nuclide vector for a facility?

2.22) Do you target a global nuclide vector for the entire facility or specific vector for individual subsystems?

2.23) How do you assess chemo-toxic material or substances? Do you correlate radio-toxicity with chemo-toxicity? Do you request material classes and chemo-toxic compound vectors? What are the main difficulties with chemo-toxic and radio-toxic standardised vectors? How do you deal with uncertainties?

2.24) Do you complement your measurement data with modelling/calculations? How?

2.25) How preliminary characterisation is used for subsequent clearance process?

2.26) How preliminary characterisation is used for subsequent classification of waste and waste treatment process?

2.27) How preliminary characterisation is used for planning decontamination actions?

2.28) How cartography is used for planning site remediation actions?

2.29) How initial cartography is used for the final site release process?

2.30) How preliminary characterisation is used to estimate radiation doses to workers during the decommissioning activities?

2.31) How preliminary characterisation is used to estimate environmental impact during the decommissioning activities?

2.32) How preliminary characterisation is used for estimation of amount of waste produced?

2.33) How preliminary characterisation is used for estimation of decommissioning cost?

2.34) Do you apply operational characterisation during the dismantling process? If yes, how it is used to estimate radiation doses to workers during the decommissioning activities?

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APPENDIX 2

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Public End-Users answers to questionnaire

When allowed by the End-Users Group member, the filled questionnaires are reported in the following appendix (questions 1.1 to 1.11).

APPENDIX 2.1: EnergoRisk (Ukraine) - arturgm@mail.ru

APPENDIX 2.2: Nuclear Damage Compensation and Decommissioning Facilitation Corporation (Japan) - Kato-kazuyuki@ndf.go.jp

APPENDIX 2.3: SCK-CEN (Belgium) - sven.boden@sckcen.be

APPENDIX 2.1: EnergoRisk (Ukraine)

T2.1: End users requirements for initial characterisations of contaminated sites and structures in constrained environment

1.1) Describe synthetically the process for a site/plant characterisation process in your country/organisation

In Ukraine gathering, processing and storage of RAW carry out at:

- The NPPs sites (SUNPP, ZNPP, KhNPP, RNPP).
- Waste disposal points of the RADON special complex.
- Waste disposal and temporary localization RAW points in the Chernobyl NPP alienation zone.
- In the storages of scientific research centers of Kiev Nuclear Research Institute and National scientific research center "Kharkov Physical-Technical Institute" so on.
- Storages of the "IZOTOP" OSC.
- Storages and structures of the "Vostochny GOK" enterprise.
- Storages and structures of the "Prydneprovsky" chemical plant.
- RAW producers areas till the moment of RAW processing and longtime storage.
- Unorganized storage in the "Shelter" object.

RAW processing include following stages:

1. RAW gathering.

   Gathering is carry out in the enterprises that produce the RAW or in the area of radioactive accident elimination. At the RAW gathering their volume and activity assessed, then RAW are placed into the containers, that guarantee the RAW nuclear and radioactive safety during the temporary storage.

2. RAW transportation.

   After RAW gathering and classification RAW are transported in the points of their processing or temporary storage. The special transport vehicles used equipped with container systems designed for different RAW transport.

3. RAW treatment.

   RAW treatment objective is to decrease the RAW volume and to transform RAW into the stable chemical state. The main methods of RAW processing are: burning, evaporation of liquid RAW and compression.

4. RAW Immobilization.

   RAW immobilization process is to place RAW into a special container or to include RAW into the cement matrix for temporary storage.

1.2) Describe the regulatory framework for decommissioning and dismantling (D&D) activities in your country.

- Applicable laws and regulations

Under decommissioning and demounting the appropriate programs were developed based on the requirements of applicable laws and standards:

1. General Safety Regulations under Decommissioning of the Nuclear Power Stations and Research Nuclear Reactors. NP 306.2.02/1.004-98.
2. Main Sanitary Rules on the Ukraine Radioactive Safety. OSPU-2005. DSP 6.177 2005 09 02.
3. General Safety Regulations for Nuclear Power Stations. NP 306.2.141-2008.
4. SOU-N JAEK 1.007:2007 Project of the NPP Unit Decommissioning. Requirements on the Scope and Content. Guideline.
5. Law of Ukraine "About Licensing in Nuclear Power Use", January, 11, 2000 № 1370-XIV.
6. Law of Ukraine "About Nuclear Power Using and Radioactive Safety" №39 / 95-VR от 08.02.1995.
7. NRBU-97. Ukrainian Standards of Radioactive Safety, National Commission of Ukrainian Population Radioactive Defense, 1997.

5. NP 306.6.124-2006. Standards of Nuclear and Radioactive Safety under Radioactive Materials Transport PBPRM-2006.
6. LAW of Ukraine "About Radioactive Waste Treatment", 30.06.1995 г. N 255/95-VR.

These laws and standards determine recommendations and requirements on safety ensuring under all stages of nuclear facilities decommissioning and RAW treatment, including gathering, transportation, processing, immobilization and storage. e.

- Did these laws preach for immediate dismantling or deferred dismantling? Please develop more about the followed strategy (waiting period, safe enclosure, entombment, etc.) in the case of deferred dismantling.

According to the regulatory guides, before decommissioning the facility should ne preliminary exposed to decay of short-living radionuclides and decrease of activity for mid and long-living radionuclides.

Preliminary exposition may be performed during several years to several decades and depends on the specific characteristics of decommissioning object and availability of infrastructure needed for decommissioning (RAW processing plants, temporary storages and so on). During the preliminary retention the decommissioned object is preserved to avoid the radioactive materials diffusion due to mechanisms, systems or structures destruction. During the preliminary retention the following are carry out:

1. Radiative investigation of the object to determine volume and main RAW characteristics.
2. Based on the determined RAW characteristics to choose or build enterprises for treatment and immobilizations of RAW.
3. Based on information about volumes of different RAWs and treatment methods it is possible to determine the needed capacity of RAW storages and build if necessary appropriate storages.
4. The licensing plan is developed, the decommissioning program and SAR are developed to obtain the decommissioning license.

Preliminary retention of object allow:

1. To reduce the RAW activity and amount.
2. To reduce the doze load for the staff working on decommissioning.
3. To reduce influence on biosphere under working on decommissioning.
4. To reduce the needed material and financial resources for decommissioning.

   Direct decommissioning begin after preparation of all needed infrastructure and obtained license on decommissioning from the state regulatory body - State Committee on Nuclear and Radiation Safety (SNRIU).

- Please specify, by clicking directly on the corresponding boxes below, the main target followed for D&D activities in your country.

✓ Deconstruction, remediation and release of the site (green field)

☐ Release of existing buildings and plants for other industrial uses

☐ Further nuclear use

- Which authorities are involved?

During all stages of decommissioning the Ukrainian Regulatory Authority (State Nuclear Regulatory Inspectorate of Ukraine, SNRIU) implement inspection and licensing of decommissioning and treatment of RAW or spent nuclear fuel (SF). Any activity on decommissioning is possible only after obtaining the appropriate license from the state license body.

The activities on treatment and long-time storage of RAW have been produced in the result of decommissioning activity also supervised by the state regulatory during all operational time of the objects on RAW treatment.

- How is the licensing process?

During all stages of decommissioning State by the SNRIU implement licensing of decommissioning.

It is necessary to obtain the state license for beginning of every stage: cessation of operation, preliminary retention, decommissioning.

Activity during the stage of cessation of operation is made in the frameworks of operational license, but for realization of this stage an individual permission is needed.

To obtain such permission the licensee should submit the following documents:

- The program on decommissioning;
- Safety Analyses Report;
- Changes in technical specifications for operation.

The main document for decommissioning activity is the decommissioning program, approved by the SNRIU. This program should include the programs for radiation protection, RAW treatment and quality assurance.

- How long it takes to get an authorisation?

Obtaining of permission on decommissioning works may be taken from one year to decades. It depends on the facility complexity, it's description, supposed volume and activity of RAW, availability of appropriate infrastructure on RAW gathering, transport, storage, disposal.

- How collaborative is the regulatory body?

Regulatory body is closely involved in decommissioning activities. To start decommissioning it is necessary to obtain licenses from SNRIU. The main documents that should be reviewed and accepted by SNRIU are: decommissioning conception, decommissioning design, decommissioning safety analyses report. In the process of decommissioning the SNRIU provide regulatory control and monitoring of compliance the license conditions (inspections, periodic reports. Etc.).

- Please specify the existing infrastructure for radioactive waste disposal in your country and at your sites, their status (intermediate or definitive) and their capacity?

In Ukraine gathering, processing and storage of RAW carry out at:

- - The NPPs sites (SUNPP, ZNPP, KhNPP, RNPP).
- - Waste disposal sites of the RADON special complex.
- - Waste disposal and temporary localization RAW points in the Chernobyl NPP alienation zone.
- - In the storages of scientific research centers of Kiev Nuclear Research

Institute and National scientific research center "Kharkov Physical-Technical Institute" so on.

- - Storages of the "IZOTOP" OSC.
- - Storages and structures of the "Vostochny GOK" enterprise.
- - Storages and structures of the "Prydneprovsky" chemical plant.
- - RAW producers areas till the moment of RAW processing and longtime storage.
- - Unorganized storage in the "Shelter" object.

All listed storages intended for intermediate RAW storage.

1.3) How are defined the goals for the characterisation?

RAW are specified by the main parameters according to OSPU-2005. The main RAW characteristics that determine requirements for treatment, immobilization, storage and disposal are:

1. The value of the half-life of radionuclides (short, medium and long-lived).
2. Activity (high (heat-emitting, low-temperature), medium, low).
3. Physical and chemical properties (volume, mass, liquid/solid, combustible/un-combustible, compressibility and so on)
4. Isotope composition (α,β,γ – active radionuclides).

In the moment of RAW generation and beginning of RAW treatment they should be described by all listed parameters that determine possible treatment methods and requirements on storage assuring.

There are levels of exemption (release) from regulatory control. All that above the levels are related to radioactive waste and the handling of these materials in accordance with the current rules and regulations for the management of radioactive waste

1.4) What is your strategy about the soils?

Now the contaminated soils depends on the degree of contamination may be removed with filling up the "clean" soil and disposal in waste disposal places. For soils with contamination degree less than degree of unconditional resettlement it is possible the concrete casting of homestead and soil's liming.

The soils removed should be disposed in the surface storages of trench type.

1.5) How the sampling plan is determined?

- Sampling strategy

Now legislative stated the requirements on treatment, storage and disposal of RAW of different modes. The most rigid requirements and respectively resource-demanding are formed for long-living RAW with high activity. The most soft requirements and respectively more inexpensive are formed for short-lived RAW with low activity. Respectively, characterization and sampling performed for the most complete RAW characterization and possibility of using more simple methods of RAW treatment.

The first activity measurements carry out in the places of RAW location by doze capacity measure at the surface.

Determination of activity mode α,β,γ – active. At first stage perform in the RAW locations.

Measurements perform sequentially. If RAW are of high activity then measurements of radio-nuclides life time are not needed, because requirements on their storage are independent from the life time. If RAW are of medium or low activity, then should be performed measurements of isotope composition and isotope life times.

Laboratory investigations of samples are necessary for determination of radionuclide vectors – activity correlations between reference (easy measured) radionuclides and difficult measured radionuclides. Radionuclide vectors determine for RAW group of similar nature (e.g., for single type technological process on single type facilities).

- Balance between destructive and in-situ analyses

Most measurements perform at the RAW location places. Laboratory investigations are needed only in a case of impossibility to determine the RAW characteristics which influence on the requirements for storage and disposal. Laboratory investigations perform for radionuclides of one group, if the preliminary measurements showed that these RAW may be disposal with more simple technology.

- Cost/benefit analysis

Cost/benefits analysis perform singly for even project at the stage of technical-economic justification based on the choice of RAW treatment technology and RAW characteristics. The main is correlation of high activity and medium/low activity wastes. If amount of RAW with medium/low activity which allow more simple disposal is not large, then the detail analysis and fragmentation is beside the purpose, taking into account for building of appropriate facilities.

1.6) Which are the key points in a characterisation plan?

Key points for planning of RAW characterizations are:

1. Characteristics of RAW source.
2. Aggregate state of RAW
3. Definition of RAW activity.
4. Definition of RAW activity’s distribution (surface or volume).
5. Levels of release from regulatory control

6. Definition of the time of life of RAW.

1.7) What is the target level of uncertainties and how are they assessed?

RAW that are the isotope composition characterized by the most conservative (complicate for treatment and storage) characteristic – activity or time of life. Also, one have a possibility to divide the single group of RAW by classes. Dividing of RAW will require more detail determination of radiation characteristics distribution, also implementation of additional technological cycles and respectively the dividing settings. Thus, the uncertainty level of RAW characterization is determinate with interrelation of cost for additional investigations and technological procedures to economy of financial means due to simplification of subsequent storage and RAW treatment.

The uncertainty level should be determined for each RAW group individually.

1.8) Which are the major difficulties/obstacles/problems that you face in characterising a plant?

The major difficulties in the RAW characterizing related to performing the detail analyses for RAW with characteristics close to dividing classes of RAW. Also, there are difficulties under correct construction of radionuclide vectors.

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1.9) Do you use software (and/or mathematical approach) to operate the results of the measures?

To model the changes of RAW characteristics during the preliminary retention and storage use the RAW mathematical model.

To assess the doze power and characterizing the single groups of RAW the doze power been calculated at surface and at distance of 1 m from source, using the appropriate computer programs.

Mathematical models use to model the transfer of radioactive materials and safety analysis on RAW treatment under normal and accidental operation.

1.10) Do you identify tools that you would wish to have in order to improve the characterisation?

To improve the characterization measurements promotes the presence of mobile highly sensitive apparatus allowing to execute the spectrometry analysis (alfa and gamma spectroscopy) including the volume activity.

There is a lack of sufficient high-resolution spectrometric equipment for large volumes of radioactive waste

1.11) Do you see benefits from a potential homologation on international standards (to be developed) in the field of site characterisation?

There is generous amount of RAW in Ukraine with low level of potential dangerous, but which have a formal signs of long-live RAW, that require implementing the special measures on storage and disposal. A new method of RAW characterization (e.g. project INSC U4.01/08-C "Improving of system of RAW classification in Ukraine" will solve the problem of long-time safety storage and disposal of RAW with acceptable costs.

APPENDIX 2.1: Nuclear damage Compensation and Decommissioning Facilitation Corporation (Japan)

T2.1: End users requirements for initial characterisations of contaminated sites and structures in constrained environment

1.1) Describe synthetically the process for a site/plant characterisation process in your country/organisation

An operator is responsible to characterise a site/plant in Japan. In Fukushima Daiichi NPS, TEPCO is doing environmenatl monitoring of sea waster, soil, etc. Waste generated by accident is characterised by JAEA as a national R&D project. Surface dose rates for segregation and storage are measured by TEPCO NDF oversight their avitivities and plan the R&D project.

1.2) Describe the regulatory framework for decommissioning and dismantling (D&D) activities in your country

- Applicable laws and regulations

The Reactor Regulation Act determine the framework for D&D activities for normal operating reactors. This law may be applicable to the accident reactor.

- Did these laws preach for immediate dismantling or deferred dismantling? Please develop more about the followed strategy (waiting period, safe enclosure, entombment, etc.) in the case of deferred dismantling.

Regulator will check and review the D&D plan made by operartor, but a favorable D&D strategy is not determined in the law. However the funding system for D&D assumed immediate dismantling

- Please specify, by clicking directly on the corresponding boxes below, the main target followed for D&D activities in your country.

☑ Deconstruction, remediation and release of the site (green field)

- ☐ Release of existing buildings and plants for other industrial uses
- ☐ Further nuclear use

- Which authorities are involved?

NRA (Nuclear Reguration Authority)

- How is the licensing process?

Operaor submit the D&D plan to NRA. Some reactors were already approved for D&D. At the end of D&D activities, the completion of D&D will be confirmed by NRA. The standards for the completion are not determined yet.

- How long it takes to get an authorisation?

Typically one year

- How collaborative is the regulatory body?

In the licensing process: None JAEA support NRA by R&D activities which are useful for regulation.

- Please specify the existing infrastructure for radioactive waste disposal in your country and at your sites, their status (intermediate or definitive) and their capacity?

Electric power companies established JNFL as a disposal company. JNFL has a LLW diposal facility that is concreat pit type at near surface. Its licensed capacity is 80,000m3. JNFL has a future plan to extend the capacity up to 600,000m3. JAEA has a trench type diposal facility for a research reactor on its site.

1.3) How are defined the goals for the characterisation?

One goal is to be the basis for the design of disposal facility. Another goal is the establishment of the nuclide concentration confirmation method for wastes to be diposed of.

1.4) What is your strategy about the soils?

Not determined yet. But it is one of key issues because the amount of comtamineted soil by 1F accident is huge.

1.5) How the sampling plan is determined?

- Sampling strategy

In 1F site, the priority of D&D activities is very high, so sampling activities for precise characterisation is done subsidiary. At this time, characterisation of 1F waste is examined as R&D by IRID. The analysing plan for obtained samples is determined by IRID. Main target is to know the characteristics of unknown waste. This results will be used to make a strategy for processing and disposal of 1F waste

- Balance between destructive and in-situ analyses

In the 1F D&D project, the characterisation is still in very early stage. Above balance is not well studied yet.

- Cost/benefit analysis

We are not in this stage.

1.6) Which are the key points in a characterisation plan?

Target wastes will be categorised for many waste streams because of wide variety of nuclide composition and concentration. Considering the load of waste characterisation, reasonablly efficient analysing method is welcome.

1.7) What is the target level of uncertainties and how are they assessed?

Not determined yet.

1.8) Which are the major difficulties/obstacles/problems that you face in characterising a plant?

Target wastes will be categorised for many waste streams because of wide variety of nuclide composition and concentration.

Additionally some chemical substances may be mixed because of several emergecy actions done at the first stage of accident.

1.9) Do you use software (and/or mathematical approach) to operate the results of the measures?

Not yet.

1.10) Do you identify tools that you would wish to have in order to improve the characterisation?

Not determined yet. But the represetativeness of a sample is imprortant to optimise the number of samples to be analysed.

1.11) Do you see benefits from a potential homologation on international standards (to be developed) in the field of site characterisation?

For 1F waste characterisation, many analysing methods which are different from previous method will be adapted. In this case, how to get the authorisation by regulator is extremely important. The existence of international standards will be helpful for 1F D&D.

APPENDIX 2.1: SCK-CEN – Belgian Nuclear Research Center (Belgium)

T2.1: End users requirements for initial characterisations of contaminated sites and structures in constrained environment

1.1) Describe synthetically the process for a site/plant characterisation process in your country/organisation

There is no specific legislation existing. Based on REX from the first D&D projects, the Belgian authorities (FANC & BEL V) have drafted two position papers: one position paper for the release of buildings and one position paper for the release of sites . However, the level of detail in relation to the initial characterization process is rather limited.

General principles described in various international documents are usually followed (Historical Site Assessment, Initial Characterization, etc.). In some specific cases we make use of geostatistics.

1.2) Describe the regulatory framework for decommissioning and dismantling (D&D) activities in your country

- Applicable laws and regulations

Royal Decree 1991/10/16 (ONDRAF/NIRAS): general management of all nuclear waste in Belgium, strategy waste management, inventory, agreement on decommissioning plans and follow-up of decommissioning projects

Law 1997/12/12: Inventory Technical Liabilities (ONDRAF/NIRAS)

Royal Decree 2001/07/20 (FANC/AFCN):

- general mission concerns protection against ionized radiations;
- licenses:
    - transport of radioactive material;
    - nuclear installation (from commissioning up to decommissioning);
    - releases of air and evacuation of effluents;
    - free release of material coming from nuclear sites;
    - control of non-nuclear installation (handling of Natural Occurring Radioactive Material).
- acting by its own means or by subcontractors

RD 2001/07/20 article 17.2 (FANC/AFCN): The decommissioning of certain nuclear facilities (class I and some class II facilities) requires a decommissioning license, which must be given prior to any decommissioning work

- Every phase in decommissioning also needs the prior approval of the Health Physics responsible and the authorized inspection agency. (license condition).
- Decommissioning work that was started before the publication of the RD, can continue, if a decommissioning license request was introduced before 2002/09/01. (article 81.2 RD 2001/07/20)

RD 2002/11/18 (ONDRAF/NIRAS): agreement for the physical, chemical and radiological characterization of waste and measuring devices and methods

- Did these laws preach for immediate dismantling or deferred dismantling? Please develop more about the followed strategy (waiting period, safe enclosure, entombment, etc.) in the case of deferred dismantling.

The Belgian legal framework does not specifically mention details regarding the strategy (e.g. immediate or deferred dismantling). Usually reference is made to IAEA defined strategies (DECON, SAFSTOR, Entombment)

- Please specify, by clicking directly on the corresponding boxes below, the main target followed for D&D activities in your country.

■ Deconstruction, remediation and release of the site (green field)

☐ Release of existing buildings and plants for other industrial uses

☐ Further nuclear use

- Which authorities are involved?

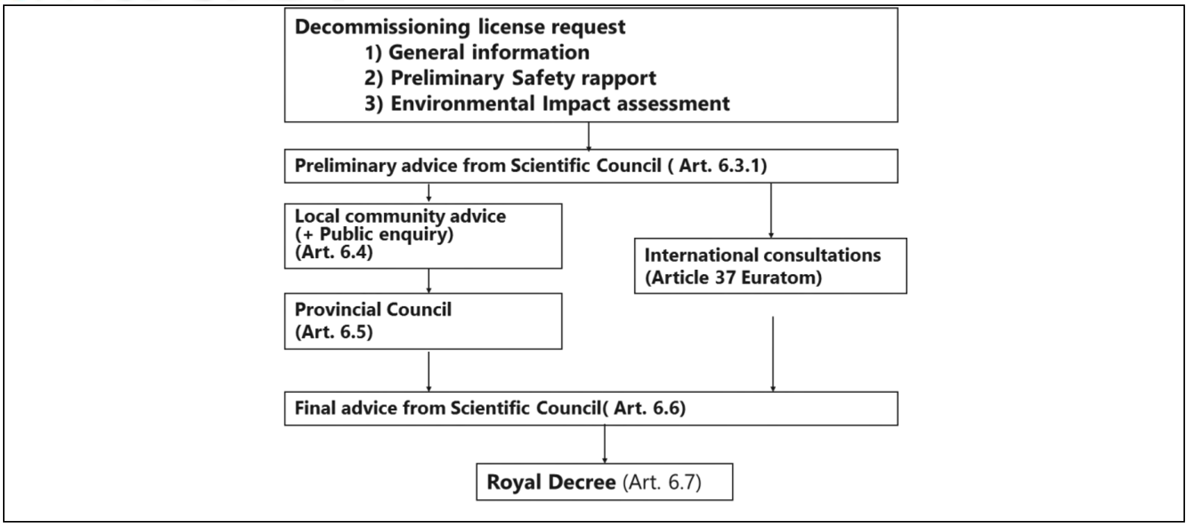
FANC/AFCN (Federal Agency for Nuclear Control)

BEL V (Competent authority in the field of nuclear applications and subsidiary of the FANC/AFCN)

NIRAS/ONDRAF (Belgian National Agency for Radioactive Waste and enriched Fissile Material)

- How is the licensing process?

For class I facilities the process is the following:



- How long it takes to get an authorisation?

About 1~2 year

- How collaborative is the regulatory body?

- Please specify the existing infrastructure for radioactive waste disposal in your country and at your sites, their status (intermediate or definitive) and their capacity?

Reprocessing of spent fuel has been carried out by AREVA (formerly COGÉMA) in France since 1978. In December 1993, the federal parliament imposed a moratorium for a period of five years on further reprocessing of the spent fuel from NPP's. In 1998, the Council of Ministers requested SYNATOM not to sign any new reprocessing contract without its formal approval. Commercial spent fuel is separately stored in dedicated facilities on the sites of the nuclear power plants (pool storage in Tihange and dry storage in Doel).

A surface storage of category A waste (radioactive short-lived waste) is foreseen to be built in Dessel. The licensing process is still running. For category B and C waste (high-level and/or long-lived waste) R&D is ongoing but no principal governmental decision has been made so far.

The interim storage facilities for conditioned waste of all categories are centralised on the Dessel site operated by BELGOPROCESS, a subsidiary of NIRAS/ONDRAF.

- Intermediate storage of low-level waste:

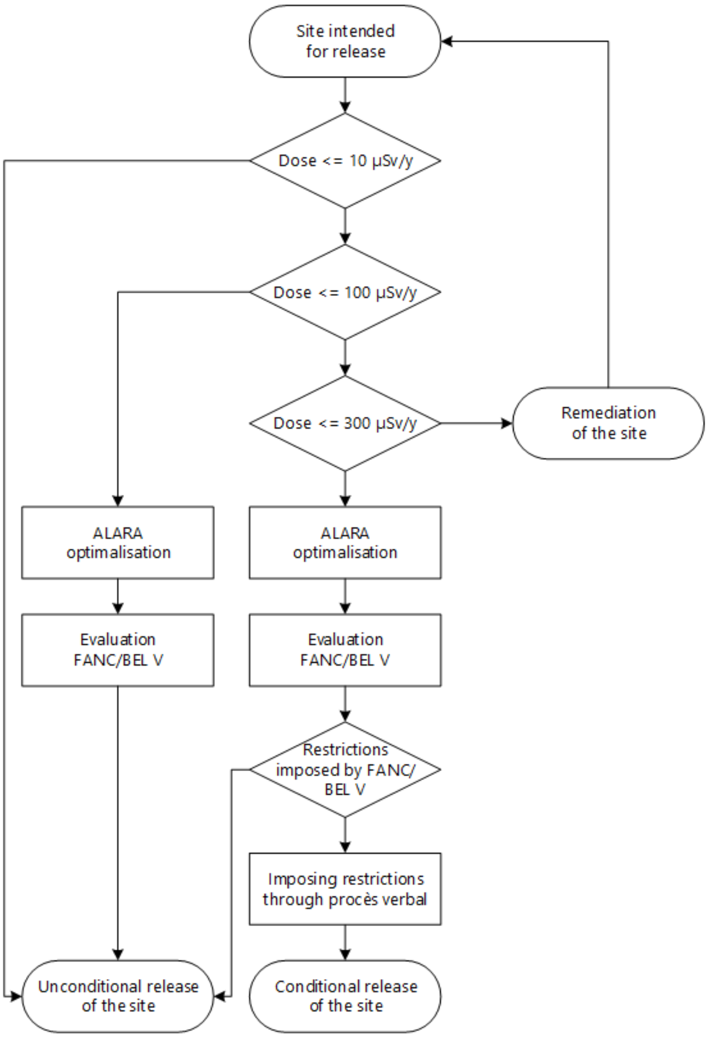
- Building 150: capacity 1.922 m³
- Building 151: capacity 14.700 m³

- Intermediate storage of medium-level and high-level waste:
  - Building 129: capacity: 250 m³
  - Building 136: 590 containers of high-level vitrified waste and about 1.000 m³ of medium-level cemented or compacted waste

1.3) How are defined the goals for the characterisation?

1.4) What is your strategy about the soils?

The position of the Belgian authorities regarding the release of soils/land is the following



1.5) How the sampling plan is determined?

- Sampling strategy

Historical assessment, initial survey based on various NDA techniques followed by DA.

- Balance between destructive and in-situ analyses

Large amount of relatively cheap NDA versus lower amount of more expensive DA

- Cost/benefit analysis

See above

1.6) Which are the key points in a characterisation plan?

Good knowledge of objectives and requirements (acceptance criteria)

Knowledge of the history

Radionuclides of importance

Validation, QA/QC

Criteria for data evaluation

1.7) What is the target level of uncertainties and how are they assessed?

Confidence level to be agreed upon with authorities

From conservative assessment to standard error propagation (1st & 2nd order Taylor expansion) up to the use of Monte Carlo simulation

1.8) Which are the major difficulties/obstacles/problems that you face in characterising a plant?

Insufficient historical data available

1.9) Do you use software (and/or mathematical approach) to operate the results of the measures?

Case by case evaluation R-study

1.10) Do you identify tools that you would wish to have in order to improve the characterisation?

1.11) Do you see benefits from a potential homologation on international standards (to be developed) in the field of site characterisation?

Mainly benefits in terms of guidance. Standardization is sometimes too restrictive and sometimes obstructs further development.