
# Benchmarking Analysis of Member States Approaches to Definition of National Inventories Radioactive Waste and Spent Fuel

*No. ENER/2018/NUCL/SI2.778797*

## Final report

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# 1 Abstract

The methods and tools used by Member States (MS) for the preparation of radioactive waste and spent fuel inventories differ greatly in the European Union. In the absence of specific guideline regarding inventories, MS limit their publications to quantity and waste categories assessments. In most cases the information available in the literature on inventories' preparation could lead to question the quality and accuracy of national inventories.

Despite the differences observed at the European Union scale, MS follow similar approaches and methods, with a level of details and complexity adapted to the country challenges. Inventories are the results of regular data collection from radioactive waste producers. However, most of the MS do only limited proof reading and review mechanism for the collected date, such as cross checking of data provided by licensees/producers and challenging quality of inventory data (conditioned or unconditioned waste, units used for waste quantities). Potential for improvement lies in the spreading of best practices identified in different MS.

Radioactive waste and spent fuel inventories' homogenisation could be achieved through the development of a specific guideline for future reports in application of the Directive 2011/70, describing in detail the formal outputs required by European Commission to improve the reporting on the inventory accuracy. However, most of the Member States already have their own best practices in line with country's needs, thus such modification of the reporting approach could lead to non-negligible additional work while providing uncertain added value for MS. While it is clear that there are important and relevant historical reasons why Member States had developed different systems, the introduction of the Directive has established Union level requirements that shall be abided to. First and foremost, the Member States have to establish and implement their national program, including inventories which have to be meaningful to serve the program implementation.

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Les méthodes et outils utilisés par les Etats-Membres pour la préparation des inventaires de déchets radioactifs et combustibles usés diffèrent fortement au sein de l'union européenne. En l'absence de Directive définissant spécifiquement les attentes concernant les inventaires, les Etats-Membres limitent leurs publications à une évaluation quantitative en lien avec leur propre classification. Dans la plupart des cas, les informations accessibles publiquement décrivent de façon limitée la préparation des inventaires et peuvent mener à questionner la qualité et la justesse des inventaires nationaux.

Malgré les différences constatées à l'échelle de l'Union Européenne, les Etats-Membres utilisent des approches et méthodes assez similaires, avec un niveau de détail et de complexité adapté à leurs propres challenges. Les inventaires demeurent le résultat de campagnes régulières de collecte d'information auprès des producteurs de déchets. Cependant la plupart des Etats Membres font une vérification et une relecture limitées des données et des mécanismes de collecte, telles que les vérifications croisées fournies par les producteurs de déchets, ou l'analyse critique des résultats des inventaires (déchets conditionnés ou non-conditionnés, unités des quantités calculées). Un potentiel

d'amélioration réside dans la généralisation des bonnes pratiques identifiées chez les différents Etats-Membres.

Une homogénéisation des inventaires de déchets radioactifs et combustibles usés pourrait être rendue possible au travers d'un guide spécifique décrivant précisément les attentes de la Commission Européenne pour améliorer l'élaboration des futurs rapports en lien avec la Directive 2011/70. Cependant, la plupart des Etats-Membres disposent déjà de bonnes pratiques en lien avec leurs besoins nationaux, une telle modification des approches nationales pourrait conduire à un volume de travail additionnel conséquent, avec une valeur ajoutée incertaine. Même si l'on reconnait qu'il y a eu d'importantes raisons historiques qui ont conduit les Etats Membres à développer différents systèmes de gestion des inventaires, la Directive a établi un niveau d'exigence au niveau de l'Union Européenne, qui doit être suivi par chaque Etat Membre. D'abord et avant toute chose, chaque Etat Membre doit établir et mettre en œuvre leur Programme National de Gestion des déchets radioactifs et de combustibles usés, en établissant leurs inventaires, en cohérence avec le Programme National.

# 2 Executive summary

## 2.1 Context of the study

**The large disparity of approaches for drafting the radioactive waste and spent fuel inventories makes the European Commission to consider the implementation of a benchmarking study, in order to assess the adequacy of the methods used by Member States and identify the best practices to spread across European Union.**

The Council Directive 2011/70/Euratom defines the legal context in which Member States shall develop and implement national programmes for spent fuel and radioactive waste. In its article 12 c) the expectations related to wastes inventories are outlined, leaving Member States responsible for the way they are reporting to European Commission.

The first and second reports to the Commission on the MS implementation of the Directive, highlighted the great variety of approaches, and level of details used by MS for the preparation and reporting of radioactive waste and spent fuel inventory. Given this situation, the European Commission launched the present study whose objective is to perform a benchmark analysis of the MS radioactive waste and spent fuel inventories, and the approaches leading to their preparation and publication. The European Commission aims at improving its understanding of the methodologies used by Member States to develop current inventories. This will contribute to the justification of the accuracy and the compelling nature of Member States national inventories. Such improvements can only come from a better self-explanation by Member States of the methods, approaches and tools used by the different national stakeholders to prepare inventories.

The present study aims at assessing whether these approaches are consistent and in line with the challenges faced by radioactive waste and spent fuel inventories in the EU. Achieving assurance of the adequacy and quality of the national inventories for spent fuel and radioactive waste will provide confidence in the stakeholders and decision makers on the cost estimations, concepts and plans for long term management of these materials, as well as in the overall national programmes for management of spent fuel and radioactive waste, as required by Article 12 (1) of the Directive.

The implementation of this study was done through a Member State exhaustive analysis (*national documentation, questionnaires…*), followed by a detailed benchmarking (*more than 20 parameters assesses*) of the current situation at the country and EU scale, identifying best practices, limitations and approaches used by MS.

## 2.2 Radioactive waste classification and waste strategies

**The Member States radioactive waste and spent fuel strategies directly impact the way the national tools and methods are structured: from national classification to management routes. Comparison between two Member States can only be performed on the tools and methods, and not the outputs** *(the same "raw" radioactive wastes can be categorized and managed differently from one country to another)***.**

The radioactive wastes and spent fuel management is a national-only issue, each Member State is responsible for developing its own approach, consistent with its legal framework, safety and management objectives (underground disposal only, sending back radioactive wastes, minimization of volume….). However, national legal framework should follow the Council Directive requirements, legally transcribed in national law by each Member states. Each country has its own strategy, at the origin of all the developments and actions performed by stakeholders (classification, management routes…).
The stakeholders in charge of the preparation of licensees' and national inventories differ among Member States: from national waste agencies, Ministries, to public or private entity in charge of waste management.

All the **radioactive waste classification in-use in Member States are not necessarily supported by a legal framework**, some being the result of past "good practices" in line with MS radioactive waste installations. Despite this, the use of a non-binding or a regulatory-supported waste classification does not appear as an issue, as long as the classification used is in line with the Member State waste management strategy.

**In different Member States, the IAEA GSG-1 is used as a radioactive waste classification, despite not formally being one**. For example, thresholds between categories are not defined for some MS's, thus such classification cannot be used on an operational basis. Using the IAEA GSG-1 classification as a starting point, some Member States need to develop their own classification, defining thresholds, half-life… Member States application of GSG-1 qualitative recommendations does not guarantee a uniformity of national waste classification across EU (thresholds and half-lives may differ from one country to another for the same waste category).

Over EU-28 the national radioactive waste classifications are widely used when establishing national inventories, with minor discrepancies not affecting the overall quality and accuracy of the inventories.

The waste management routes are well identified in Member States official publications. The installations needed to safely manage radioactive wastes are identified and developed, the key challenge being in the construction of these facilities rather than their definition. Geological disposal is discussed in various Member States, but these projects are progressing very slowly.

**Most of the Member States have radioactive waste classification in line with international recommendations from IAEA, and best practices and supported by a specific legal framework. Most of them developed radioactive waste classification in total adequacy with their country needs. In some cases, due to technical considerations and/or typology of wastes the waste classification is simplified or based on a fully different approach.**

**Most of the Member States use their waste classification to report their national inventories. However, there are cases where inventories are reported based on existing waste management facilities, temporarily used as storage,**

**waiting for clarification on future final disposal decision. In such cases, inventories are not fully in compliance with waste classification, mostly established for final disposal.**

## 2.3 Radioactive waste and spent fuel current inventories: methods, approaches and tools

While it is mandatory for Member State to report on a regular basis on their current radioactive waste and spent fuel inventories, **the approaches, methods and tools used by each Member State are under their sole responsibilities and are generally not communicated publicly**. There are many reasons explaining the general lack of information regarding the way national inventories are prepared in the Member States official publications:

- It can first be seen as a direct consequence of the absence of requirements defined by European Directives; Member States are limiting themselves to the reporting of the topics identified in the article 12 of Council directive 2011/70/Euratom.
- This lack of national inventories justification can also be considered as the result of a "non-systematic and proven" approach, where the general process of gathering, compiling and publishing inventories is unclear, based on variable approaches, with ongoing improvements;

**The limited information available regarding the approaches used by Member States to prepare national inventories could lead to question the quality and accuracy of the national inventories. Nevertheless it has been checked, based on National reports, that Member states inventories (current and future) are consistent with hypothesis taken by MS's as far as their nuclear programmes are concerned (life extension, nuclear new build, research reactor closures, nuclear phase out, existing waste unconditioned or conditioned, etc…).**

Therefore, regarding the evaluation of the overall radioactive waste activities in the European Union, no major discrepancies have been noted during the benchmark study. Spent fuel, high-level waste and intermediate level waste (long-life) are closely monitored by national and international organizations, especially spent fuel in the frame of safeguards requirements.

The present inventories are composed of radioactive wastes already produced and/or conditioned and/or stored. For this reason, no major variations should also be expected. **One fundamental principle of radioactive waste management and planning is the consideration of error margin and over-dimensioning to cope with uncertainties**.

Ultimately, this analysis of EU-28 national inventories and associated tools, methods and approaches, is consistent with a continuous improvement approach, that could lead in the near future to a better definition of inventories, through the wider use of best practices and guidelines.

**The various potential uncertainties on radioactive waste quantities are almost never formally included in the inventories, despite being identified by some radioactive waste stakeholders.** It is considered that current inventories are for the

majority accurate, by essence uncertainties are included at the waste package level, but not on a global basis.

The inventories do not systematically include all the radioactive wastes in the management routes, for more than half of MS, unretrieved, untreated and/or unconditioned wastes are excluded. On a global scale, such approach does not generate major discrepancies in the inventories, only a delay for their consideration as radioactive wastes.

**A good practice to limit uncertainties** *(lack of global vision due to the non-systematic inclusion of radioactive wastes still in the early phase of management routes, and non-consideration of radioactive materials not yet considered as radioactive wastes)* **would be to remind for future reports, that "radioactive waste management" means all activities that relate to handling, pre-treatment, treatment, conditioning, storage or disposal of radioactive waste (cf art (8) of the Directive 2011/70/Euratom**

The information regarding the location of radioactive wastes and spent fuel in EU Member State can be generally found in national reports and publications. MS either directly specify the location for each identified waste family, or they describe in detail the characteristics of the waste management installations and management routes, allowing to identify the waste location based on its nature.

Regarding the current inventories of radioactive wastes and spent fuel, the Member States often adhere to minimum the requirements of the Council Directive 2011/70/Euratom, which does not specify to give detail on the methods, tools and approaches used for the preparation of national inventories, nor on the uncertainties.

A specific survey regarding these methods/tools/approaches allowed to identify the main patterns used for the inventories' preparation. They are generally the result of self-declarative evaluation from licensees that fill and forward "databases" to the entity in charge of the inventory consolidation.

In most cases, proofreading processes are limited, no particular "back-and-forth process" is reported between licensees' and inventory responsible. Consistency of the data transmitted is checked during the inventory preparation. The frequencies of update of the inventories vary among Member States, and is often linked to the frequency at which data are collected: for MS with automatized systems (*i.e. online transmission of data*) the inventories are continuously updated and regularly published, while MS relying on periodic surveys can only update their inventories after each survey.

## 2.4 Radioactive waste and spent fuel future inventories

**The Member States generally follow the same approach for current and future inventories, most of the findings developed previously remain applicable for future inventories.**

The key challenges regarding the preparation of future inventories are:

- The uncertainties related to the mid/long-term estimates, especially the consideration of decommissioning wastes;

- The approach used to quantify future waste fluxes (*business as usual as compared to specific assessments*);
- The uncertainties regarding European nuclear programmes, with major societal challenges for renewal and/or decommissioning of nuclear power plants. The waste production chronicles associated remain uncertain.
- The changes in the MS legislation which would be necessary to cope with evolution on the management of radioactive waste and spent fuel.

Decommissioning wastes are almost systematically included in the future inventories of radioactive wastes.

Limited information is given on the way future radioactive waste volumes data are estimated or gathered. This situation is similar to the lack of information observed for approaches, tools and methods of current inventories.

Nevertheless, different approaches are used, depending on the Member States, to evaluate the future quantities of radioactive wastes and spent fuel:

- For MS with limited volumes of wastes coming from a small number of waste producers, the future wastes fluxes are generally assessed on the basis of the historical yearly waste generation. An approach "business as usual" is commonly used to estimate the future inventories at key dates.
- For MS with large volumes of wastes, specific developments are generally performed. In the case of decommissioning activities for example, the year-per-year generation of wastes estimated in the decommissioning plan can be used to assess the future wastes volumes. Average historic fluxes are often used for assessing operating wastes per installation.

## 2.5 Management system and record keeping of national inventories

Over the EU-28, the standardized communication approach used between licensees and authorities appears efficient and adapted to the specificities of radioactive waste and spent fuel inventory preparation. Licensees are responsible for the accurate and exhaustive transmission of information, while authorities are in charge of compiling and preparing the national inventories.

Licensees communicate information in line with authorities' expectations (forms, template, online database…), this allows authorities to update (generally on a yearly basis) and publish inventories at the desired frequency.

The record keeping mechanisms are different for medium and long-term, and shared between licensees and storage/disposal operators and waste management organisations. For long-term record keeping, situation is different as most disposal facilities are not yet built, this open issue is under consideration and various possibilities are explored while long-term disposal facilities are being developed.

## 2.6 Recommendations

In the absence of a detailed framework for the preparation and publication of radioactive waste and spent fuel inventories, each Member State has adopted its own strategy. Although this benchmark study across the 28 MS's has concluded that their current

inventories are well developed, it remains room for improving important aspects he development of a reference European guideline (on the model of IAEA guidelines), on how Member States should gather data, prepare inventories and communicate could lead to a better spreading of best practices that already exist in some Member States. However, RW and SF challenges are specific to Member States waste management specificities, thus succeeding in finding a "one fit for all" approach needs to be discussed with MS's in order to find the best way and their commitment for improving the current preparation of inventories across the European Union..

Alternatively, the EC may decide that it would prefer not to propose a common methodology as this may cause difficulties for some individual member states to comply, given their situation. In this case the EC could consider developing a guideline or even requirement that each MS publishes a document to accompany each revision of the inventory which explains in detail how the MS has produced the inventory, with commentary on the process, the exchange of data between licensees and the central inventory body, how they have considered decommissions wastes, uncertainties etc. In this way a process of "self-improvement" may be promoted. With each MS now more open to question by its own stakeholders, the public and their peers, with no MS likely to want to operate a process of significantly less effectiveness the other 27 MS's. By promoting this visibility of "best-practice" the EC may enable MS's to learn from others and develop a more effective process that best suits their situation.
It is noted that, in meeting with the 5 visited MS's, it was clear that the process of compilation of the inventory was better developed and more controlled than is explained by much of the published documentation. This may suggest that development of national inventories across the entire EU is better than may initially appear and may support the suggestion above that published methodology documents would be a useful contribution to both understanding and continuous improvement through exchange of best practices

# 2 Résumé du Rapport

## 2.1 Contexte de l'étude

**La forte disparité des approches utilisées pour l'élaboration des inventaires de déchets radioactifs et combustibles usés a conduit la Commission Européenne à mettre en place une étude comparative, afin d'évaluer la pertinence de ces approches utilisées par les Etats-Membres ainsi que d'identifier les bonnes pratiques à partager au sein de l'Union Européenne.**

La Directive du Conseil Européen 2011/70/Euratom définit le contexte légal dans lequel les Etats-Membres développent et appliquent leurs programmes nationaux pour la question des combustibles usés et déchets radioactifs. Dans l'article 12 c), les attentes relatives aux inventaires sont définies, laissant les Etats-membres seuls responsables de la structure et l'approche utilisée pour leurs rapports vers la Commission Européenne.

Les premiers et seconds rapports d'application de la Directive par les Etats-Membres pour la Commission Européenne, ont permis de souligner une grande variété d'approches, et de niveaux de précision développés par les Etats-Membres lors de la préparation des inventaires de déchets radioactifs et combustibles usés. À la suite de ce constat, la Commission Européenne a lancé la présente étude comparative des inventaires de déchets radioactifs et combustibles usés, et notamment des approches conduisant à leur préparation et publication.

L'objectif de cette étude consiste à évaluer la pertinence des approches utilisées par les Etats-Membres pour la préparation des inventaires. S'assurer de la pertinence et de la qualité des inventaires de déchets radioactifs et combustibles usés renforcera la confiance du public dans les estimations de coûts, les concepts et scénarios de gestion à long terme, ainsi que dans les programmes nationaux pour la gestion des déchets radioactifs et combustibles usés, comme requis par l'article 12 c) de la Directive.

La réalisation d'une telle étude s'est effectuée sur la base d'une analyse approfondie de chaque Etat-Membre (documentation nationale, questionnaires…), suivi d'une analyse comparative détaillée (plus de 20 paramètres analysés) de la situation actuelle pour chaque pays, en identifiant les bonnes pratiques, les limites et les approches employées.

## 2.2 Classification et stratégie déchets radioactifs

**Les stratégies de gestion des déchets radioactifs et combustibles usés pour chaque Etat-Membre impactent directement les outils et méthodes utilisés pour la préparation des inventaires : depuis la classification des déchets jusqu'au filières de gestion. Les comparaisons entre Etats peuvent seulement s'effectuer sur la base des outils et méthodes et non pas des quantités (un déchet radioactif pourra être catégorisé et traité différemment selon les pays).**

La gestion des déchets radioactifs et combustibles usés demeure une problématique nationale, chaque état étant responsable du développement de sa propre approche, en ligne avec son contexte règlementaire, sa sûreté nucléaire et ses spécificités de gestion

(stockage géologique uniquement, retour des déchets aux producteurs, minimisation des volumes…). Chaque pays a développé sa propre stratégie, qui influence directement l'ensemble des actions entreprises par les différents acteurs du secteur (classification des déchets, définition des filières de gestion…). Les acteurs nationaux en charge de la préparation des inventaires diffèrent selon les états : agence nationale des déchets, ministères, entités publiques et privées en charge de la gestion des déchets.

**Toutes les classifications de déchets radioactifs en vigueur ne font pas nécessairement l'objet d'un cadre règlementaire**, certaines classifications n'étant que le résultat de « bonnes pratiques » historiques basées sur les installations existantes de gestion et traitement des déchets radioactifs. Malgré cela, l'utilisation d'une classification non-inscrite dans la loi n'apparait pas comme un enjeu, dès l'instant où la classification utilisée est en ligne avec la stratégie nationale de gestion des déchets.

**Différents Etats-Membres utilisent le guide de l'AIEA GSG-1 comme une classification de déchets, bien qu'il n'en soit pas une.** Par exemple, les seuils entre les différentes catégories de déchets ne sont pas définis précisément, empêchant de facto l'utilisation rigoureuse de telles classifications. Le guide GSG-1 de l'AIEA peut néanmoins être utilisé comme un point de départ, pour permettre la définition d'une classification nationale, avec la définition de seuils, de demi-vies… L'application par les Etats-Membres des recommandations qualitatives du guide GSG-1 ne garantit pas forcément une uniformité des classifications de déchets (les seuils et demi-vies diffèrent entre Etats pour une même catégorie de déchets).

A l'échelle de l'Union Européenne, les inventaires nationaux s'appuient sur les classifications nationales de déchets. Les quelques écarts qui existent n'affectent pas la qualité et la pertinence de ces inventaires.

Les filières de gestion des déchets sont correctement identifiées dans les publications des Etats-Membres. Les installations nécessaires pour la gestion de ces déchets sont correctement identifiées et détaillées, les enjeux se trouvant dans la construction de ces installations plutôt que dans leurs définitions. Les solutions de stockage géologique sont étudiées dans de nombreux Etats, mais les projets avancent peu.

**La grande majorité des Etats-Membres s'appuient sur des classifications définies par un cadre règlementaire, le plus souvent en phase avec les recommandations internationales et les bonnes pratiques du secteur. La plupart des Etats ont su développer une classification en adéquation totale avec les besoins du pays. Dans certains cas, la prise en compte de considérations techniques, ou la typologie très spécifique des déchets peut conduire à la simplification des classifications, voire l'élaboration d'approches diamétralement différentes. L'utilisation des classifications nationales est bien répandue, et les Etats-Membres les utilisent quasi-systématiquement lors de la structuration de leurs inventaires.**

## 2.3 Inventaire de déchets radioactifs et combustibles usés : méthodes, approches et outils

Les Etats-Membres doivent régulièrement faire état de leurs inventaires de déchets radioactifs et combustibles usés. **Les approches, méthodes et outils utilisés restent sous leur responsabilité et ne sont que rarement détaillés dans la littérature publique.** Il y a de nombreuses raisons à l'origine de ce manque d'information :

- En premier lieu, l'absence de détails dans les rapports nationaux sur ces sujets peut directement être perçu comme la conséquence directe d'une non-définition des attentes de la Commission Européenne au sein de l'article 12 de la Directive du Conseil Européen EURATOM 2011/70. Les Etats se limitent à communiquer les informations demandées au sein de la Directive.
- L'absence de justification de ces méthodes peut également résulter d'une « approche non-systématique et éprouvée », où le processus général de collecte, compilation et publication des inventaires est incertain, basé sur des approches variables, en perpétuelle évolution.

**Le peu d'information disponible concernant les approches utilisées par les Etats-Membres pour la préparation des inventaires nationaux amène à s'interroger sur la qualité et la pertinence desdits inventaires. Néanmoins, il convient de considérer que même en cas d'imprécisions, les inventaires apparaissent comme suffisamment représentatif de la réalité.**

En ce qui concerne l'évaluation globale de l'activité des déchets au sein de l'Union Européenne, les incertitudes apparaissent limitées, car les combustibles usés, les déchets haute-activité et moyenne activité vie longue sont suivis de près par les organismes nationaux et internationaux, notamment pour des considérations de garanties AIEA.
Les inventaires sont essentiellement composés de déchets radioactifs déjà produits et/ou conditionnés voire stockés. Pour cette raison, aucune variation majeure des stocks existants n'est à considérer. **Il convient également de rappeler qu'un des principes fondamentaux de la gestion des déchets présente et future réside dans la prise en compte d'incertitudes et de marges de sécurité, conduisant au surdimensionnement des différentes installations et procédés pour permettre la prise en compte desdites incertitudes.**
Enfin, cette analyse des inventaires européens et leurs outils, méthodes et approches associées apparait cohérente dans une approche d'amélioration continue, qui doit permettre dans un futur proche d'améliorer la préparation des inventaires, au travers d'un partage des bonnes pratiques et méthodes employées.

Les nombreuses incertitudes potentielles sur les quantités de déchets ne sont quasiment jamais formellement incluses dans les inventaires, malgré leurs identifications par certains Etats-Membres. La précision des inventaires n'est pas contestée, par principe, les incertitudes sont incluses au niveau du colis de stockage/entreposage mais jamais à l'échelle de l'inventaire national.

Les inventaires nationaux n'incluent pas systématiquement l'ensemble des déchets radioactifs dans les filières de gestion, pour plus de la moitié des Etats-membres, les des déchets non-traités, non-collectés ou non-conditionnés sont exclus des inventaires

actuels. Une telle approche ne génère pas d'incertitude majeure, mais repousse néanmoins ultérieurement leur prise en compte dans l'inventaire.

**Une bonne pratique pouvant permettre de limiter les incertitudes** (manque de vision globale suite à la non-considération systématique des déchets présents en amont des filières de gestion, ou la non-considération des matériaux radioactifs non-encore considérés comme des déchets) **serait de redéfinir la notion d'inventaire de « déchets radioactifs » en rappelant que le périmètre inclus bien l'ensemble des activités relatives au transport, pré-traitement, traitement, conditionnement, entreposage et stockage des déchets radioactifs** (cf. article 8 de la Directive 2011/70).

L'information concernant la localisation des déchets radioactifs et combustibles usés dans les Etats-Membres peut être facilement trouvée dans les rapports nationaux et autres publications. Les Etats-Membres précisent soit directement la localisation de chaque famille, soit une description détaillée des caractéristiques des installations de gestion des déchets et les filières de gestion associées, permettant l'identification des déchets selon leur natures.

En ce qui concerne les inventaires actuels de déchets radioactifs et combustibles usés, les Etats-Membres s'en tiennent au prérequis de la Direction 2011/70, qui ne demande pas de détails vis-à-vis des outils, méthodes et approches pour la préparation des inventaires, de même que pour les incertitudes.

Une étude spécifique des méthodes, outils et approches auprès des Etats-Membres a permis d'identifier les principales tendances pour la préparation des inventaires. Ceux-ci sont généralement le résultat d'auto-déclaration des producteurs de déchets, qui remplissent et transmettent des bases de données complétées auprès des entités en charge de la consolidation des inventaires.

Dans la plupart des cas, les processus de relecture sont limités, peu « d'allers-retours » de l'information sont mentionnés entre les producteurs et les responsables de l'inventaire. La pertinence des données transmises est vérifiée durant la préparation des inventaires. La fréquence de mise-à-jour des inventaires diffère selon les Etats, et apparait souvent liée à la fréquence de collecte de l'information. Pour les Etats avec des procédés automatisés (i.e. transmission online des données) les inventaires sont continuellement mis à jour et publiés régulièrement, là où les Etats s'appuyant sur des sondages périodiques peuvent seulement mettre à jour les inventaires après chaque itération des sondages.

## 2.4 Inventaire futurs de déchets radioactifs et combustibles usés

**Les Etats-membres suivent généralement la même approche pour les inventaires actuels et futurs, la majorité des observations énoncées précédemment s'appliquent également aux inventaires futurs.**

Les principaux challenges associés à la préparation des inventaire futurs sont :

- Les incertitudes liées aux estimations à moyen/long terme, en particulier en ce qui concerne les déchets issus des opérations de démantèlement ;

- Les approches utilisées pour quantifier les flux futurs de déchets (approches « business as usual » ou au travers d'évaluations dédiées) ;
- Les incertitudes liées aux programmes nucléaires civils européens, avec l'ensemble des enjeux sociétaux associés à la construction de nouvelles centrales nucléaires ou le remplacement du parc existant. Les chroniques de production associées restant incertaines.
- Les modifications dans la législation des Etats-Membres, qui peuvent porter sur la gestion des déchets radioactifs et combustibles usés.

Les déchets de démantèlement sont la plupart du temps inclus dans les inventaires futurs. Néanmoins, les inventaires ne contiennent que peu de détails sur la façon dont ses quantités sont estimées. De même, les approches, outils et méthodes ne sont que très rarement évoqués dans ces inventaires futurs :

- Pour les Etats-Membres avec de faibles volumes de déchets, provenant d'un nombre limité de producteurs, les flux futurs sont généralement estimés sur la base des flux moyens historiques. Cette approche « business as usual » est utilisée pour estimer les inventaires à des dates futures données.
- Pour les Etats-Membres avec d'importants volumes de déchets, des études spécifiques sont généralement effectuées. Dans le cas des déchets de démantèlement par exemple, les flux de déchets annuels provenant des plans de démantèlement sont utilisés pour bâtir les chroniques des inventaires futurs. Les flux moyens historiques sont quant à eux utilisés pour établir les volumes de déchets d'exploitation des installations en fonctionnement.

## 2.5 Systèmes de management et conservation des inventaires

Au sein de l'Union Européenne, les mécanismes d'échanges entre les producteurs de déchets et les autorités compétentes apparaissent adaptés aux spécificités liées à la préparation des inventaires de déchets radioactifs et combustibles usés. Les producteurs de déchets sont responsables de la pertinence et la qualité des informations transmises, là où les autorités nationales ont la responsabilité de collecter et compiler ces informations.

Les producteurs communiquent des données en fonction des attentes des autorités (formulaires, remplissage de base de données en ligne…), ce qui permet aux autorités de mettre à jour leurs inventaires (généralement sur une base annuelle) tout en les publiant à la fréquence souhaitée.

Les mécanismes de conservation de données sont différents à moyen et long-terme, et restent partagés entre les producteurs de déchets, les opérateurs des installations de stockage et d'entreposage et les organisations nationales en charge des déchets. En ce qui concerne la conservation à long terme, les choses sont différentes, car les installations de stockage définitif ne sont pas encore en service, ces questions demeurent donc en suspens et de nombreuses approches sont aujourd'hui à l'étude.

## 2.6 Recommandations

En l'absence de cadre précis européen pour la préparation et la publication d'inventaires, chaque Etat-Membre a su développer sa propre approche. Cette multitude d'approche rend complexe la coordination et l'analyse de ces inventaires au sein de l'Union Européenne. Le développement d'un guide commun (sur la base des guides AIEA), développant une approche-type sur la manière dont les Etats pourraient rassembler les informations, préparer et communiquer les inventaires, pourrait permettre une meilleure généralisation des bonnes pratiques qui existent dans certains pays. Néanmoins, la problématique des déchets radioactifs et des combustibles usés demeure une problématique nationale, il n'est donc pas aisé de concevoir une approche unique satisfaisant chaque Etat et ses spécificités intrinsèques. Il est nécessaire de discuter avec les Etats Membres la meilleure solution et leur engagement pour améliorer la situation actuelle de la préparation des inventaires des déchets radioactifs au sein de l'Union Européenne.

À la suite de ce constat, la Commission Européenne pourrait ne pas vouloir imposer une méthodologie commune, qui risquerait de créer des complications dans son application selon les Etats. Dans ce cas la Commission Européenne pourrait envisager d'imposer aux Etats de détailler l'approche utilisée dans chaque révision de leurs inventaires, en décrivant les modalités de compilation, la méthode de collecte de données, les échanges entre parties intéressées, l'approche utilisée pour la considération des déchets de démantèlement, les incertitudes… Une telle approche favoriserait une démarche d'amélioration continue. Cette approche de questionnement du grand public sur ces grands sujets sociétaux pousse les Etats-Membres à mieux se challenger entre pays. En soutenant cette approche d'auto-amélioration, la Commission Européenne peut permettre aux pays d'apprendre les uns des autres en développant des approches plus performantes adaptées aux besoins de chacun.

L'étude a permis de rencontrer 5 Etats-Membres au sein de réunion dédiées, et il apparait clairement que les approches utilisées pour la compilation et la préparation des inventaires sont structurées et matures. Cela suggère que la préparation des inventaires au sein de l'Union Européenne est bien plus performante que le constat que l'on peut faire à la lecture des publications des Etats Membres. Ces observations renforcent l'approche consistant à demander aux Etats de publier de plus amples détails sur les approches utilisées, et pourrait donc permettre de satisfaire les besoins de compréhension du grand public et des autorités, tout en partageant les bonnes pratiques à l'échelle de l'Union Européenne.

# 3 Forewords

## 3.1 Background

In accordance with Article 11 and Article 12 of Council Directive 2011/70/Euratom (further "the Directive"), Member States shall develop and implement national programmes for spent fuel and radioactive waste management that implement in practice the national policies - from generation to disposal of these materials.

The Directive requires that the national programme shall include among others "an inventory of all spent fuel and radioactive waste and estimates for future quantities, including those from decommissioning, indicating the location and amount of the radioactive waste and spent fuel in accordance with appropriate classification of the radioactive waste" (see Article 12(1)c). The programmes shall also include concepts and plans, research, development and demonstration activities, costs and financing mechanisms for implementation of the programmes, key performance indicators for monitoring of the programme's implementation. In addition, Member States shall report on the implementation of the Directive every 3 years (starting 23 August 2015) and on the basis of these reports the Commission shall report the EU inventory and the future prospects to the Council and the European Parliament.

The first report of the Commission on progress of Member States implementation of the Directive was adopted on 15 May 2017 (COM(2017)236).

## 3.2 Objectives of the study

The European Commission contracted the Consulting Company NucAdvisor to perform this study covering the 28 Member States, whose general objective is to analyse and benchmark the national radioactive waste and spent fuel inventories of the EU Member States, including the approaches used by Member States for their development.

Achieving assurance of the adequacy and quality of the national inventories for spent fuel and radioactive waste will provide confidence in the stakeholders and decision makers on the cost estimations, concepts and plans for long term management of these materials, as well as in the overall national programmes for management of spent fuel and radioactive waste, as required by Article 12 (1) of the Directive.

The present study analyses:

- at Member States level - the national inventories' data quality, completeness and accuracy of methods for data collection, tools and standards employed for data management, estimation methodologies, tools/methods for future inventories estimations and identification/treatment of uncertainties;
- at EU level – common aspects with respect to radioactive waste classification, good examples and challenges with respect to the collection, and management of data, as well as estimation of current and future inventories, including identification and treatment of uncertainties.

The study's scope covers both spent fuel (from all sources) and radioactive waste from nuclear and non-nuclear applications (*incl. orphan sources and NORM waste that are declared as radioactive waste by the Member State concerned*). All sources of radioactive waste and spent fuel will be covered, including waste from operation,

decommissioning and remediation of contaminated facilities and sites, as well as future returns of radioactive waste from spent fuel reprocessing and radioactive waste processing abroad (all waste from weapons programmes being excluded).

During the implementation of the study a specific attention has been paid to:

- the various national requirements for national inventories;
- radioactive waste classification schemes, their correspondence to the IAEA classification (see Safety Guide No. GSG-1) and their application in practice;
- methodology and tools to establish the current inventories and future estimates corresponding to the timeframes of the national programme for spent fuel and radioactive waste management (data collected and used – e.g. waste characteristics and location);
- comprehensiveness of national inventories (e.g. identification of gaps in inventory reporting) and approach(es) to review and update of the national inventories.

The study covers latest national inventories available (2013 and 2016), future estimates (*up to the latest available period*) and any available information for intermediate steps (*e.g. 2020, 2030 or other reference date*) until the end of the national programme in force in the country. The study has been performed while taking into account all relevant national and international information on national inventories, in particular:

- national programmes on spent fuel and radioactive waste as per Article 13 and national reports of Member States on implementation of the Directive as per Article 14(1) of the Directive;
- the Report from the Commission to the Council and the European Parliament on progress of implementation of Council Directive 2011/70/Euratom (COM(2017)236) and an inventory of radioactive waste and spent fuel present in the Community's territory and the future prospects (SWD(2017)161);
- the available Member States reports under Article 32 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (5th and 6th review meetings);
- any other relevant information on national inventories available to the Commission (DG ENER.D).

## 3.3 Implementation of the study

The study has been implemented by an expert team composed of specialists mainly coming from the European radioactive waste sector (*national waste agencies, radioactive waste facility operators…*). The 28 Member States to be investigated were split among experts (7 profiles mobilized over the 18 months-period), with a joint methodology and follow-up to by Project Leader to ensure the consistency of the analysis over the European Union.

After an initial phase of data gathering and analysis of the existing European documentation, a detailed assessment of the situation of each of the 28 Member States has been performed by the team. The purpose of this assessment was to develop with the same methodology a synthesis of the radioactive waste and spent fuel situation:

- Sources of radioactive wastes and spent fuel;
- Major stakeholders for the development, review and update of national inventories of spent fuel land radioactive waste;

- Classification of radioactive waste;
- Approaches, methods and tools for current national inventories of spent fuel and radioactive waste;
- Approaches, methods and tools for future estimates for spent fuel and radioactive waste;
- Management system and record keeping of the national inventory;

These 28 Member States monographs can be found in this report appendices. The expert team also identified some questions that were transmitted to MS representatives through a specific MS and generic questionnaires, whose answers can be found in appendices. The MS monographs were produced based on the information made available before any answers to the questionnaires were received.

After this first standard assessment, the team developed a series of indicators to support the benchmarking analysis, while covering the different topics and issues identified in §3.2. For each indicator, the team assessed the position of the 28 Member States. The different indicators are summarized in the following tables:

**Table 1: Indicators for classification systems and inventory data**

| Indicator | Purpose |
|---|---|
| Member State legal or regulatory framework regarding the development and review of inventories | To analyse the exhaustiveness of the legal or regulatory framework defining the responsibilities, approach and outputs regarding the development and review of inventories. |
| Member State legal framework of the national radioactive waste classification | To analyse the development status of the national radioactive waste classification, and its integration within the Member States legal framework. |
| Member State scope of the national radioactive waste classification | To analyse the coverage of the national radioactive waste classification, based on international standards (in particular IAEA GSG-1) and its adequacy with the Member States requirements. |
| Member States application of the national radioactive waste classification | To analyse the application of the national classification in the radioactive waste management Member States' process, and the licensees' and national inventories. |
| Member State consideration of NORM radioactive wastes in the national classification and legal framework | To assess the consideration of NORM waste in the Member State legal framework, national classification and inventories. |
| Member State consideration of exempt radioactive wastes in the national classification and legal framework | To indicate whether exempt waste are defined through a legal or regulatory framework |
| Member State determination of radioactive wastes routes | To indicate if radioactive wastes routes where defined for each waste category defined in the national classification, in consistency with the IAEA GSG-1 recommendation |

**Table 2: Indicators for development of current inventories for spent fuel and radioactive waste**

| Indicator | Purpose |
|---|---|
| Reliability of tools/approaches/methods to develop current inventories | To assess the reliability of the approaches, tools and methods used to develop and update the national inventories. |
| Member States national current inventories exhaustiveness | To assess the format and level of details of the national inventories, especially the physical quantities used to assess the current inventories. |

| Indicator | Purpose |
|---|---|
| Member States current national inventories perimeters | To assess the different stages and locations of waste productions as described in the current inventories. |
| Member State national inventories wastes location | To assess the exhaustiveness of the inventories, namely on the location of the wastes and the condition of storage/disposal. |
| Member State current national inventories uncertainties | To assess the approach used by each Member States to deal with uncertainties in the national inventory. |

**Table 3: Indicators for future estimates for spent fuel and radioactive waste**

| Indicator | Purpose |
|---|---|
| Reliability of tools/approaches/methods to develop future inventories | To assess the reliability of the approaches, tools and methods used to develop and update the future national inventories. |
| Member State future national inventories exhaustiveness | To assess the format and level of details of the future national inventories, especially the physical quantities used to assess the current inventories. |
| Member States future national inventories perimeters | To assess the different stages of waste productions as described in the future inventories. |
| Member State future national inventories consideration of decommissioning wastes | To get precise information on future inventories arisings from dismantling operations |
| Member State future national inventories per classification category | To get an estimate of the amounts of waste to be generated in the future for each of the categories defined in the classification |
| Member State future national inventories uncertainties | To assess the approach used by each Member States to deal with uncertainties in the future national inventories. |
| Member State strategies for future national inventories displays | To assess the approaches chosen by Member States to display the future inventories. |

**Table 4: Indicators for management system and record keeping of national inventories**

| Indicator | Purpose |
|---|---|
| Member State update frequency of the inventories | To assess the frequency at which the inventories are updated by the different stakeholders in the Member States. |
| Member State communication procedures between national waste agencies and licensees on the inventories | To assess the approaches used by Member States to communicate information on inventories between national waste agencies and licensees, and the feedback/verification process. |
| Member State inventories record keeping | To assess the approaches used by Member States for the record keeping of the inventories. |

The information included in national literature do not describe precisely the methods, tools and approaches used by Member States for the development of current and future inventories, the management systems and the record keeping. Thus, a standard questionnaire was prepared to cover the lack of information, addressing mainly the issues related to tools, approaches and methods associated to waste inventories. This questionnaire was sent to representative of the 28 Member States (*25 answers*

*received)* in order *to obtain detailed* and up to date information to support the benchmarking process.

The team also performed 5 Member States visits (*Finland, Italy, Spain, Poland & Czech Republic*) to present and validate with countries stakeholders the preliminary findings of the study. Minutes of meetings are attached in Appendices.

The present document was presented during a dedicated workshop in Brussels the 19th and 20th of November 2019, with Member States and the European Commission participation and updated accordingly with MS inputs and outcomes.

# 4 Approaches and methods of the benchmark study

Following the implementation of the 2011/70/EURATOM directive, the Member States must periodically communicate (every three years) on their radioactive waste and spent fuel present and future situation. While the Directive precisely defines the outputs to be produced by each Member States in the frame of these follow-up reports, the approach to be used is left at the discretion of the MS.

The present study is focusing on the following objectives:

- comprehensiveness of national classification systems for radioactive waste, based on the legal requirements and the provisions of the Directive;
- completeness of the radioactive waste and spent fuel sources, management routes and their adequacy with respect to national inventories;
- approaches, methods and tools used for the current national radioactive waste and spent fuel inventories (origin of the radioactive waste and spent fuel with its volume (waste)/mass (spent fuel), volume, location and reference date and its status whether conditioned or unconditioned, process of conditioning (where possible), and whether stored and disposed of);
- approaches, methods and tools used for the review (e.g. update on regular basis) of present inventories and estimates of future national radioactive waste inventories;
- approaches, methods and means to identify uncertainties for current and future national inventories;
- inventory management systems and mechanisms in force to record keeping of national inventories and responsibilities.

Each of these topics is developed in the following chapters, through a common approach. NucAdvisor performed detailed assessments per Member State of the present situation regarding radioactive waste and spent fuel inventories based on published information, then prepared a questionnaire addressed to Member States that allowed to fill the gap in the missing information.

Following the Member States assessments and questionnaires answers (*25 MS answered to the questionnaire*), NucAdvisor developed a series of indicators covering the entire spectrum of the study, allowing to efficiently describe the status of each Member State in this field.

A preliminary screening of the Member States publications shows in almost all cases a lack of published information regarding these approaches, methods and tools used to prepare national inventories. In the absence of details, the accuracy and exhaustiveness of the inventories can be questioned. Member States communicate to the European Commission on a regular basis on the radioactive waste and spent fuel quantities, without describing the full methodology that led to such results.

**Finding #1**

**T**he approaches, methods and tools used by Member States for the definition of the present and future inventories are almost never developed or communicated in the public literature or to the European Commission. Art.12 of the Directive, does not require the reporting of the approaches, methods and tools for the development of

inventories. It is however recognized that highlighting these aspects would be helpful to progress toward a better understanding of the reported figures and to better anticipate future needs in terms of national or common infrastructures.
It is important that MS's take into consideration how to include in the national report, a description of approach/methods/tools used for the development of current inventories and future inventories as well. This will give a full confidence that MS's are thoroughly managing RAW and Spent Fuel management with exhaustiveness, accuracy and uncertainties of quantities, volumes and activities.

The results of this benchmark analysis are presented along with specific developments per Member States, identifying trends, challenges and good practices.

Each of the following chapters is dedicated to a specific issue:

§5 Classification systems and inventory data
§6 Development of current inventories for spent fuel and radioactive waste
§7 Future estimates for spent fuel and radioactive waste
§8 Management system and record keeping of national inventories

*Nota bene: In the following sections, the figures under parenthesis (xx) refer to the number of Member States in the situation discussed. Such evaluations have been performed on the basis of the analysis of MS documentation, along with questionnaires and direct discussions with 5 country representatives which were visited in June and July 2019 (Italy, Finland, Spain, Czech Republic and Poland). Practically speaking, based on these "face to face" discussions, it is considered that most of the issues are common to all Member States and have been grasped during these meetings with that 5 MS's.*

# 5 Classification systems and inventory data

## 5.1 Assessment of EU-28 situation

Before assessing the exhaustiveness of the national inventories, it is essential to first identify the context in which it will be developed. The radioactive wastes and spent fuel management being a national-only issue, each Member State is responsible for developing its own approach, consistent with its legal framework, safety and management objectives (*underground disposal only, sending back radioactive wastes, minimization of volume….*). Thus, each country has its own strategy, at the origin of all the developments and actions performed by stakeholders (*classification, management routes…*).

**Finding #2:** The Member States strategies directly impact the way the national tools and methods are structured: from national classification to management routes. Comparison between two Member States has to be performed on the tools and methods, and not the outputs (*the same "raw" radioactive wastes can be categorized and managed differently from one country to another*).

Despite having different "final objectives", each Member State has to settle a legal context in which the different stakeholders have their objectives and relations defined, along with the fundamental tools such as radioactive waste classification. This study does not aim at assessing the entire national legal contexts, but instead focuses on the requirements for development/review of licensee's inventories and national inventories for spent fuel and radioactive wastes.

### 5.1.1 Member State legal or regulatory framework regarding the development and review of inventories

The Member States regulatory framework defining the responsibilities, approach and outputs regarding the development and review of inventories are, on a general basis, relatively well developed across Member States.

Member States systematically define in their national legislation the roles and responsibilities of the various stakeholders in charge of the development and review of licensees' and national inventories. Nevertheless, the level of details regarding the approaches to be used by the stakeholders differs from one Member State to another. More than three-quarters of MS (22) defined these approaches (*namely what is expected in terms of outputs for each stakeholder, whether it's data transmission, data collection, or compiling of national inventories…*). Yet, a distinction can be made between the MS that describe in detail how these interactions and outputs for national inventories should be performed (9), and those who do not describe these precisely (13), only providing general statements on the general approach that should be used.

**Finding #3:** the stakeholders in charge of the preparation of licensees' and national inventories differ among Member States: from national waste agencies, Ministries, to public or private entity in charge of waste management.

, Based on this finding, some MS still need to better define and/or identify which entities are involved in the inventory's management and preparation. In some countries the

responsibilities are shared between various players (*e.g. Ministries are the final responsible for waste management, while national waste agencies are in charge of the operational implementation/preparation of the inventories*) which complicates the general understanding of which are the "operational" entities in charge of these tasks. All Member States have a legal framework, defining at least the stakeholder's responsibilities regarding development and review of inventories, and the approaches in some cases.

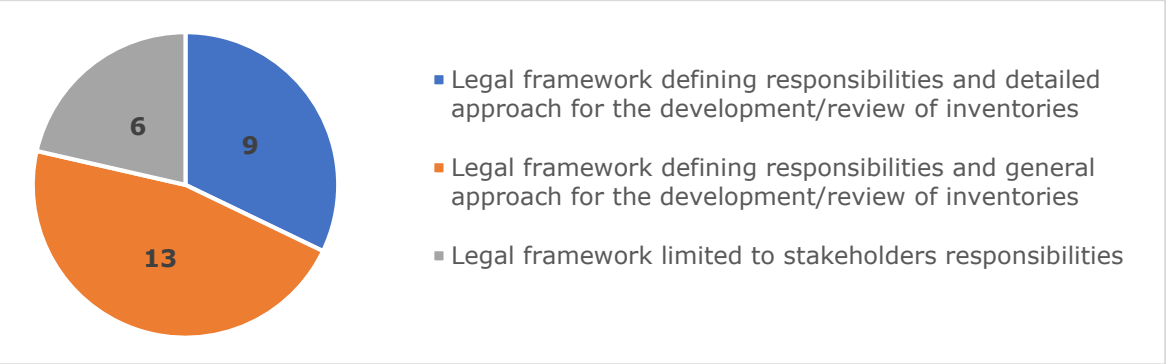


**Figure 1: Assessment per Member State of the situation regarding the development of legal frameworks**

Nota Bene: the national regulations being in each Member State official language, a formal assessment of each regulation could not be performed in the frame of this study. Most of the elements used by NucAdvisor in such analysis were coming from the "*National reports prepared within the framework of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*". A good practice seen in different national reports is the presentation in details of each article, law, decree of the national regulation describing its purpose and the associated outcomes.

### 5.1.2 Member State legal framework of the national radioactive waste classification

Before assessing the exhaustiveness of national radioactive waste classification and their adequacy with the radioactive wastes and spent fuel management, an assessment of classification's maturity has to be performed. In order to efficiently define management routes and develop a national strategy for the radioactive wastes and spent fuel, each Member States should have an operational waste classification, adapted to its needs and included in the national regulation.

Across the European Union, most of the Member States (19) developed their own radioactive waste classification and it has been formally transposed in the national regulation through a proper law or decree. Such classification is generally based on the overall strategy used by Member State for the management of radioactive waste (*either through disposal options, or national specificities…*).

For several countries (5), an operational waste classification is under use without proper associated regulation. Such classification is often derived from "good practices" and/or operational habits developed by waste operators (*e.g. radioactive waste management*

*or storage facilities operators*), but no formal regulation has been developed through the years to support such classification. The lack of legal framework does not prevent national regulators to accept such regulations, as it is the case in different Member States (*e.g. Germany where the classification in use is derived from future disposal facility acceptance criteria*), where classification has been approved by the regulator and the different stakeholders involved in the waste management field.

**Finding #4**

All the radioactive waste classification in-use in Member States are not necessarily supported by a legal framework, some being the result of past "good practices" in line with MS radioactive waste installations with subsequent acceptance by regulators.
It is recommended for those MS's, to review carefully the need to set up a legal framework.

Finally, only a few countries do not have, on purpose, national radioactive waste classification. This lack is directly linked to the limited quantities of waste and the typical range of managed wastes found in the country (*e.g. Ireland does not have any national classification, it only refers to the IAEA GSG-1 Low-Level Waste Category*).


**Figure 2: Assessment per Member State of the situation regarding the regulatory definition of the national classification of radioactive waste and spent fuel**

The use of a non-binding or a regulatory-supported waste classification does not appear as an issue, as long as the classification used is in line with the Member State waste management strategy, and is recognised by the national industry as the accepted practice as it can be seen in the following section.

### 5.1.3 Member State scope of the national radioactive waste classification

As previously stated, a national radioactive waste classification must be in line with the challenges faced by the Member States in terms of radioactive wastes and spent fuel management. The IAEA defined in its "General Safety Guide GSG-1 – Classification of radioactive waste", a standard approach for waste classification, covering all the different types of wastes possible.

Without assessing on a case-by-case basis, the integration of some waste categories (*exempt wastes, very-low-level wastes…*), a first assessment of the adequacy of the classification has been performed.

For the majority of Member States (21), the waste classification is consistent with international IAEA recommendations, covering the entire range of radioactive waste: from exempt to high-level wastes. Such MS are considered being in a position to efficiently categorize and identify any type of waste.
It must be noted that in some cases, some divergence can be observed:

- some categories can also be merged, when a common management route exist for two wastes categories (*Low and Intermediate level waste for example*), some Member State merge these categories in their classification.
- some categories can be officially excluded by Member States, in France for example as there is no clearance levels in use for solid wastes, the "exempt waste" category do not exist;

Some Member States (4) limited their waste classification, excluding the different types of wastes that do not exist in the country, without affecting the Member State capacity to handle all the present and future wastes.

Conversely, issues were identified with some Member States, where the current classifications do not cover all the different types of waste to be generated during operation and future dismantling activities. A major challenge for these countries will be to develop or update the national classification (*e.g. Member State operating research reactors are not currently managing HLW and ILW-LL but they will have to during dismantling of these installations*).

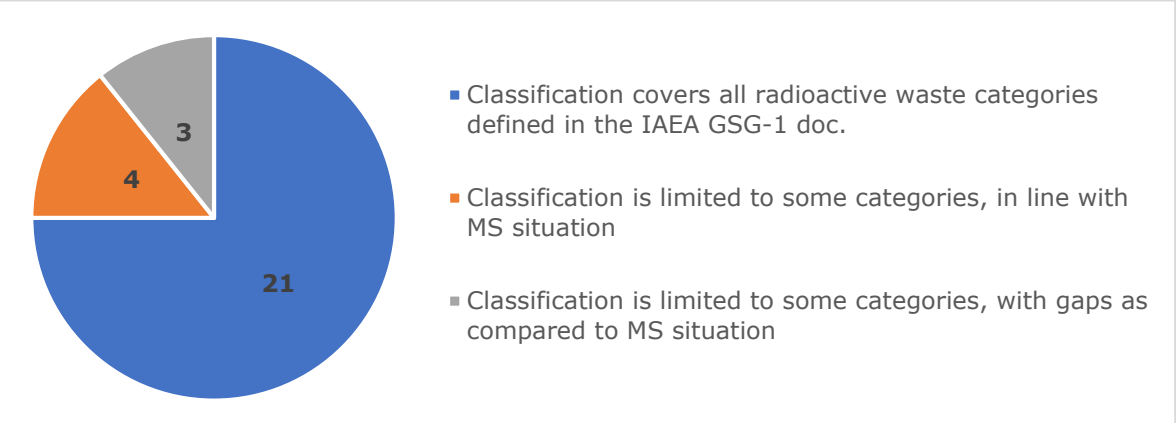


**Figure 3: Assessment per Member State of the adequacy of the national classification**

A general trend among Member States can be observed, the IAEA GSG-1 is widely being used as a reference for the definition of national waste classification. The conceptual illustration of the waste classification scheme, the management routes is well accepted and shared among Member States.

**Finding #5**

In different Member States the IAEA GSG-1 is used as a "reference classification", despite not formally being one. For example, thresholds between categories are not defined thus such classification cannot be used on an operational basis. A real effort of transposition has to be performed for some Member States to rely on a proven classification in line with the Member State needs.

Member States application of GSG-1 qualitative recommendations does not guarantee a uniformity of national waste classification across EU (thresholds and half-lives may differ from one country to another for the same waste category). Overall waste classifications are consistent in order of magnitude, but some precautions must be considered when summing up inventories to obtain a global vision at the EU level.

For those MS's it is recommended to review the needs to define thresholds in the waste classification

### 5.1.4 Member State consideration of exempt radioactive wastes in the national classification and legal framework

As defined in the IAEA GSG-1, the exempt waste category refers to waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes. Not all Member States decided to implement such approach, by defining a thresholds limit below which solid radioactive wastes can be treated as conventional wastes.

Among the Member States, only 3 have not considered "exempt wastes" as a category of their national classification: France, Luxembourg and Slovakia. For these countries all radioactive wastes coming from controlled areas have to go through the radioactive waste management routes.

### 5.1.5 Member State consideration of NORM radioactive wastes in the national classification and legal framework

The consideration of NORM (*Naturally occurring radioactive material*) is currently under discussion on the international level and in various member states. Almost all Member States have industry producing NORM residues (*Uranium mining, rare-earth extraction, oil & gas, water treatment…*) but the level of consideration of NORM residues and NORM wastes largely differ among Member States. NORM residues may be composed of reusable material; thus, all NORM residues cannot be considered as NORM waste, being a resource from industrial side.

NORM residues mainly raise issues regarding radiation protection and risk of dissemination thus potential risk for public. For this reason, various Member States decided to implement a regulatory framework around NORM.

More than half of EU Member States (18) defined NORM wastes as part of their regulation on radioactive wastes, but only a few (9) performed assessments of the volume and origin of NORM wastes and included it in their national inventories. Despite having industrial activities producing NORM wastes, some countries have not yet defined them within the national regulation.

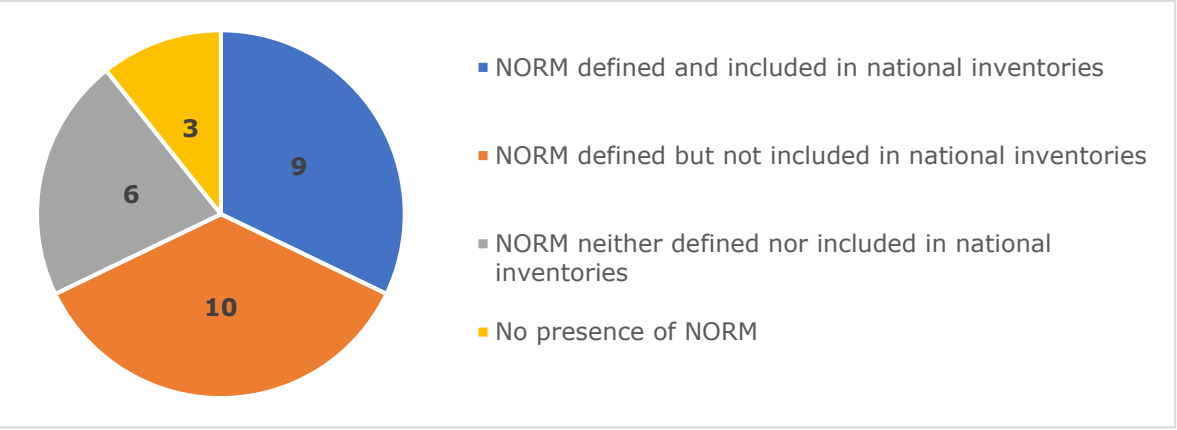


**Figure 4: Assessment per Member State of the status of NORM within the EU**

The consideration of NORM waste appears as a challenge for Member States. A formal strategy regarding NORM waste consideration, monitoring and management must be implemented by each MS. Due to the large volumes of NORM wastes, their consideration among the radioactive waste management routes could have a major impact: raising costs and modifying waste acceptance issues and leading to fastest saturation of VLLW disposal facilities.

**Finding #6:** NORM currently appear as an "open" issue within EU, MS are positioning themselves on how NORM wastes should be considered (*either as a radioactive waste, or through limited monitoring/safe storage*). The NORM consideration is expected to be clarified within the next decade. There is currently no specific European legal framework regarding NORM, a joint European reflection with Member States is required to conclude on the necessity to include NORM in the inventories.

### 5.1.6 Member States application of the national radioactive waste classification

Once a radioactive waste classification has been defined by a Member State (*either through regulation or as a "good practice"*), it is expected that such classification should be used on a systematic basis when referring to radioactive waste and spent fuel, especially for licensees' and national inventories. An analysis on the way national inventories are reported towards national classification has been performed, allowing to identify some deviations.

Less than half of Member State (11) have national inventories in which all the radioactive wastes are assigned to a category of their national classification.

For the majority of Member States (14), the national classification is predominantly used, but with minor discrepancies:

- Some radioactive wastes are not systematically assigned to a category. In some cases, the wastes are identified based on their origin, use or conditioning status (*number of radioactive sources, volume of effluent, number of waste containers…*);
- In some Member States, the national classification is used, but not for all the identified wastes. Unconditioned wastes may, for example, be mentioned but not quantified;

- Some discrepancies can also be observed between the national classification and the operational classification inside waste management/storage/disposal facilities, where different waste categories are merged removing a level of details (*e.g. a facility accepting low & intermediate level waste may sometimes refers to LILW instead of LLW and ILW as per the national classification*).

Only a limited number of countries (3) do not use national classification. However, the volumes of wastes are extremely small for these Member States (*countries with no nuclear power plants or research installations*) and they usually refer directly to the typology and origin of the waste (*e.g. sealed sources or legacy wastes*).


**Figure 5: Assessment per Member State of the national classification use when reporting national inventories in official reports**

Over EU-28 the national radioactive waste classifications are widely used when establishing national inventories, with minor discrepancies not affecting the overall quality and accuracy of the inventories.

### 5.1.7 Member State determination of radioactive wastes routes

In order to assess the robustness of each Member State approach regarding radioactive waste, it is essential to precisely detail the existing and future management routes within the Member States. IAEA recommends in its different guidelines to base waste classification on national storage/disposal facilities (existing, under study/construction or planned) that directly reflect national waste strategy.

When reporting on their waste classification the Member States almost systematically (22) associate a waste category with its detailed management route (from waste generation to safe final disposal). Even in the case where the management routes are not clearly put in parallel with radioactive waste categories, the Member States provide details on the waste management facilities (storage/disposal) and status (*in operation, planned, under construction*).

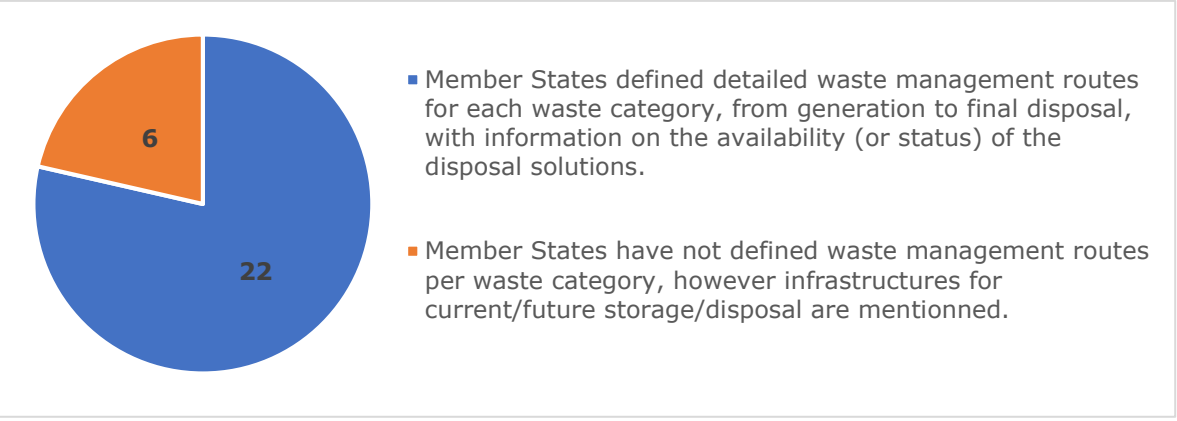


**Figure 6: Assessment per Member State of the definition of radioactive waste routes**

**Finding #7**: on a formal basis, the waste management routes are well identified in Member States official publications. The installations needed to safely manage radioactive wastes are identified and developed, the key challenge being in the construction of these installations more than their definition. Geological disposal is discussed in various Member States, but these projects are slowly progressing.

## 5.2 Summary of findings

The vast majority of Member States have radioactive waste classification in line with international standards and best practices and supported by a specific legal framework. Most of them developed radioactive waste classification in total adequacy with their country needs. In some cases, due to technical considerations and/or typology of wastes the waste classification is simplified or based on a fully different approach.

These radioactive waste classifications are widely used, and generally the Member States systematically use them to report their national inventories.

# 6 Development of current inventories for spent fuel and radioactive waste

## 6.1 Assessment of EU-28 situation

The preparation of national inventories involves various stakeholders: from waste producers to national waste agencies, covering all the existing radioactive wastes, either in the state of final disposal, temporary storage or unconditioned wastes inside producer premises.

While it is mandatory for Member State to report on a regular basis on their current radioactive waste and spent fuel inventories, the approaches, methods and tools used by each Member State are under their sole responsibilities and are generally not communicated. There are many reasons explaining the general lack of information regarding the way national inventories are prepared in the Member States official publications:

- It can first be seen as a direct consequence of the absence of requirements defined by European Directives; Member States are limiting themselves to the reporting of the topics identified in the article 12 of Euratom directive 2011/70.
- This lack of national inventories justification can also be considered as the result of a "non-systematic and proven" approach, where the general process of gathering, compiling and publishing inventories is unclear, based on variable approaches, with ongoing improvements;
- It may also be a result of simply believing that there is little interest in the information outside of those within the industry who are likely to be already familiar with it

Through this study, the European Commission aims at improving its understanding of the methodologies used by Member States to develop current inventories. This will contribute to the justification of the accuracy and the compelling nature of Member States national inventories. Such improvements can only come from a better self-explanation by Member States of the methods, approaches and tools used by the different national stakeholders to prepare inventories.

**Article 12 of Council Directive 2011/70/Euratom**

*"The national programmes shall set out how the Member States intend to implement their national policies referred to in Article 4 for the responsible and safe management of spent fuel and radioactive waste to secure the aims of this Directive, and shall include all of the following: […]*

*(c) an inventory of all spent fuel and radioactive waste and estimates for future quantities, including those from decommissioning, clearly indicating the location and amount of the radioactive waste and spent fuel in accordance with appropriate classification of the radioactive waste"*

The limited information available regarding the approaches used by Member States to prepare national inventories could lead regulators and other stakeholders to question the quality and accuracy of the national inventories.

It is nevertheless expected that even in the case of discrepancies, the Member States inventories should not be "far from reality":

- Regarding the "activity evaluation of radioactive waste in EU", no major discrepancies should be expected, as spent fuel, high-level waste and intermediate level waste (long-life) are closely monitored by national and international organizations, especially spent fuel in the frame of safeguards requirements.
- The present inventories are composed of radioactive wastes already produced and/or conditioned and/or stored. For this reason, no major variations should also be expected. The uncertainties coming from future waste fluxes are discussed in "§7: Future estimates for spent fuel and radioactive waste".
- One fundamental principle of radioactive waste management and planning is the consideration of error margin and over-estimating to cope with uncertainties.

Ultimately, this analysis of EU-28 national inventories and associated tools, methods and approaches, is consistent with a continuous improvement approach, that could lead in the near future to a better definition of inventories, through the wider use of best practices. The following sub-chapters aims at identifying the challenges, trends and good practices associated with national inventories preparation within EU-28.

### 6.1.1 Reliability of tools/approaches/methods to develop current inventories

The process leading to the publication of a national inventory differs from one Member State to another and is generally not described by the different stakeholders participating in the inventory preparation. The Council Directive does not require any particular methodology when preparing inventories, leaving to the Member States to define an appropriate approach without any expected reporting of it.

The methods/tools/approaches used by Member States are described in a limited number of cases (8). The main trend observed over EU-28 shows that the MS operating the largest numbers of Nuclear Power Plants (France, Germany, United-Kingdom, Belgium…) describe in details their national methodologies which are generally well-proven and documented, while the MS with more limited volume of waste do not generally publicly share their approaches.

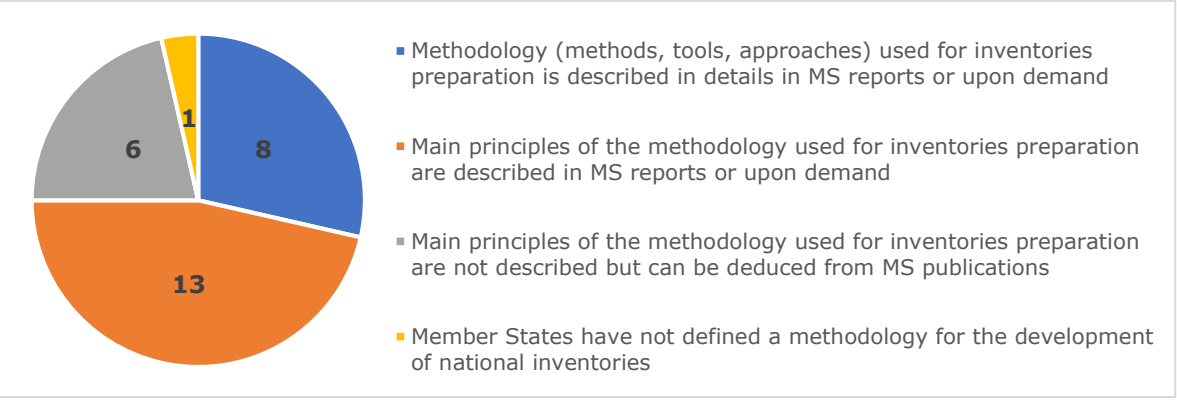


**Figure 7: Assessment per Member State on the methodology used to develop current inventories**

For most of the Member States, the general approach used to collect, verify and aggregate the inventory can be found or deduced in the national publications of the entities in charge of radioactive waste management and regulation. The main principles are often shortly described (13) or can be deduced (6) in some cases.

### 6.1.2 Member State current national inventories uncertainties

The management of uncertainties will be more largely discussed when dealing with future inventories (*see §7.1*), the main uncertainties are expected to come from the future decommissioning and nuclear site clean-up. These short/medium terms operations will generate radioactive wastes. These future waste assessments are based on a rather "theoretical" knowledge of the installations to be dismantled, but many uncertainties remain: status of the contamination of buildings and soil, accuracy of the input data used, decontamination scenario foreseen… These issues will be developed in §7.1.

It is generally considered that a good degree of confidence can be expected from current inventories. The radioactive wastes coming from the present nuclear industry and the non-power applications are since a few decades rather well identified, due to the different European and national regulations for waste producers. For the current existing radioactive wastes, the main uncertainties are essentially coming from legacy wastes and installations, used prior the implementation of efficient waste management strategies.

The Member States inventories do not mention generally any kind of uncertainties in their assessment of the present inventories. For the majority of MS (15), the uncertainties are not discussed at all in their publications.

The absence of development regarding uncertainties is generally explained by various factors:

- The uncertainties are not necessarily part of the approaches and methods used by Member States for inventory data gathering and data concatenation. The uncertainties are often considered on a waste package basis (*i.e. uncertainties on radionuclides concentration or activity for a specific waste package*), but uncertainties are almost never developed on an overall basis.

- In some cases, the inventories are limited to conditioned wastes only, thus removing any risk of uncertainty as these wastes are already safety stored or disposed.
- Uncertainties are considered by waste management organizations for the dimensioning of waste storage and disposal facilities. In practices, error margins for total waste volume acceptance are systematically considered, to cope with uncertainties on waste inventory.
- Uncertainties are part of the evaluation and figures communicated for some waste categories. For example, it is common knowledge that uncertainties usually exist for legacy waste or onsite wastes not already fully retrieved (*e.g. exact volume of liquid wastes in tanks, detailed activity per radionuclides in conditioned legacy wastes…*), thus error margins are systematically included.

**Finding #8:** the various potential uncertainties on radioactive waste quantities are almost never formally included in the inventories, despite being identified by some radioactive waste stakeholders. It is considered that current inventories are for the majority accurate, by essence uncertainties are included at the waste package level, but not on a global basis.

Some countries report the main sources of uncertainties in their present inventories (13), but only a few publicly display some assessment of the uncertainties (4).

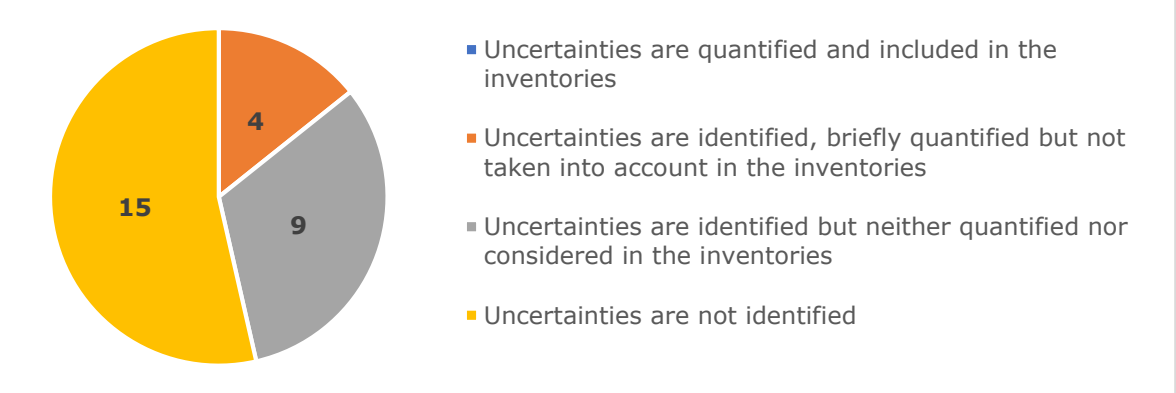


**Figure 8: Assessment per Member State of the inclusion of uncertainties in present radioactive waste and spent fuel inventories**

Although uncertainties are often not developed in public documentation, it should be noted that by definition the operational management of waste means waste producers need to consider margins and uncertainties.

Uncertainties are intrinsically part of radioactive waste inventories; the activity and exact concentration of each radionuclide cannot be fully assessed. In various cases, the rationale used by waste producers is only to cope with waste acceptance criteria (*for waste management, storage and disposal facilities*), assessing whether the waste package is acceptable in a defined category and within specific thresholds.

The conditioning process also raises uncertainties. With some wastes being unconditioned at the moment, the exact volume to be stored is still unknown, so some conservative hypothesis is being made in the vast majority of cases.

**Illustration of conditioning uncertainties mitigation approaches**

The best practice observed in different Member States consists in requesting to licensees the reporting of radioactive wastes volumes of unconditioned and conditioned wastes (*along with packages and expected waste treatment*).

In Finland for example, licensees are requested to present both: the volumes of unconditioned waste and the volume conditioned and packed waste. Such volume can be calculated as the methods and packages used in disposal are known.

In the United-Kingdom, the waste producers directly report uncertainties using lower and upper factors for the conversion between unconditioned and conditioned wastes, allowing national waste agencies to perform uncertainties assessments.

### 6.1.3 Member States national current inventories exhaustiveness

The Council Directive 2011/70/Euratom formally requests to report the "amounts of radioactive waste and spent fuel in accordance with radioactive waste classification", thus allowing each Member State to structure their inventories according to their specificities or national best practices.
Almost all Member States defined a radioactive waste classification (§5.1.2), therefore the national inventories should in theory be built upon these waste classifications. The main difference between inventories remains the level of details and the consistency of the reported figures. Depending on the status of the radioactive waste and spent fuel, the inventories can be done in terms of weight, volume, activity and any associated physical quantities.

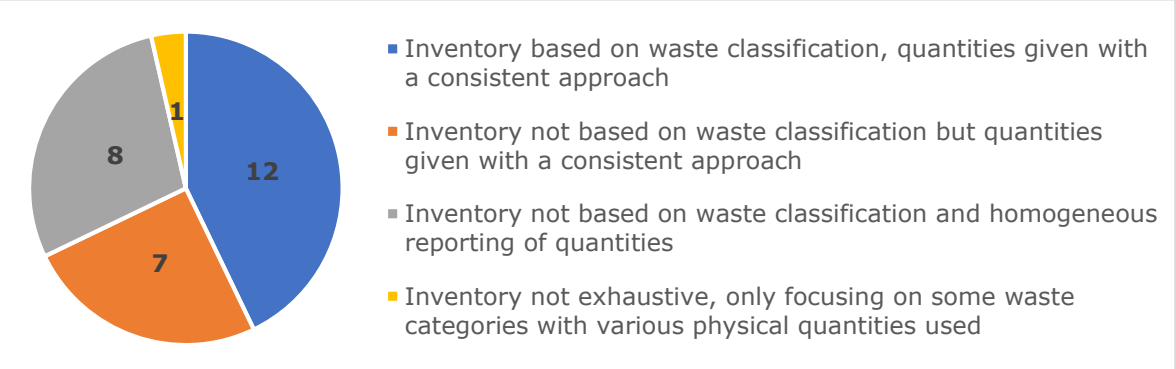


**Figure 9: Assessment per Member State of the radioactive waste inventories exhaustiveness**

In more than half of Member States, the current inventories are not fully following the national waste classification (16), such deviation being the result of multiple causes:

- Use of former waste classification, for countries where the radioactive waste classification changed in the last years;
- For MS having limited waste quantities, the inventory is sometimes based on radioactive products (number of sealed sources, number of radioactive items…), in line with a treatment on a case-by-case basis;
- In some cases, the storage/disposal facilities are the same for different categories of wastes (*e.g. for Low and Intermediate Level waste*), thus different categories are merged, resulting in a slight difference with the national classification;

The largest waste producers Member States (i.e. operating nuclear power plants) tends to prepare high-quality inventories, almost systematically following the radioactive waste classification with consistent details and physical quantities for each waste category.

Most of the Member States have shaped their inventories in a consistent way (20), the same physical quantities are used for each waste category (*cubic meters, tons, activity…*). Thus, a global overview and evolution of the MS radioactive waste situation can be easily performed.

The present and future inventories are consolidating radioactive wastes and spent fuel at different stages of the management routes (*wastes conditioned and safety stored/disposed, wastes safely stored before conditioning, in-situ wastes not yet collected…*). The preferred choice for licensees is to refer to conditioned wastes only, allowing to compare consistent figures. The hypothesis used to convert raw wastes into conditioned wastes is almost never described, while in some cases ambiguities can be found when no precision is given regarding the status of the conditioning (*raw wastes or conditioned wastes*).

**Finding #9:** national wastes classifications are not systematically respected in the inventories, Member States use different consistent approaches when referring to radioactive wastes and spent fuel, with deviations often deriving from operational choices. The distinction between conditioned/unconditioned wastes is not systematically given, same for the hypothesis used in conversion from one to the other.

### 6.1.4 Member States current national inventories perimeters

As already discussed, an exhaustive national inventory has to gather radioactive waste in various stages of their management routes (*from unconditioned wastes at licensees' premises to conditioned waste under final disposal*). Hypothesis are made to assess the final volume of conditioned wastes. Almost half of the Member States (13) have exhaustive inventories, with an evaluation of the future volumes/weights to be safely disposed in long-term facilities.

In practice, the national inventories often exclude to a certain extent some radioactive wastes (15) in order to ease to inventory preparation. Such practices have multiple origins:

- Some Member States (8) decided to exclude from their inventories the licensees' radioactive wastes that have not been yet collected by the waste management and treatment facilities. These wastes will be included in the inventories once they will pass the acceptance criteria for waste treatment or waste storage/disposal. As long as radioactive wastes are not kept for long period by licensees (*no accumulation of unconditioned raw radioactive wastes onsite*), such approach do not formally decrease the quality or exhaustiveness of the inventories. It only postpones the integration of radioactive wastes in the inventories, on a long-term basis this approach has no impact. Some countries defined by law maximum duration of waste storage inside licensees' premises (e.g. *in Denmark, after one-year, radioactive wastes at licensees' site must be discharged or transferred to national waste facility*)

- Some Member States (6) limit their current inventories on the radioactive wastes and spent fuel in a situation of safe storage/disposal. The inventory is generally limited to the collation of the inventories of the different disposal and storage facilities. This makes it difficult to draw conclusions on the exhaustiveness of the inventories, and to assess the volume of wastes not yet conditioned that are temporarily stored inside licensees' nuclear installations.
- Finally, in very specific case(s), for Member State(s) with low volumes of wastes, inventories are focused on a specific type of wastes (*generally limited to sealed sources used in the industry and the medical sector*).

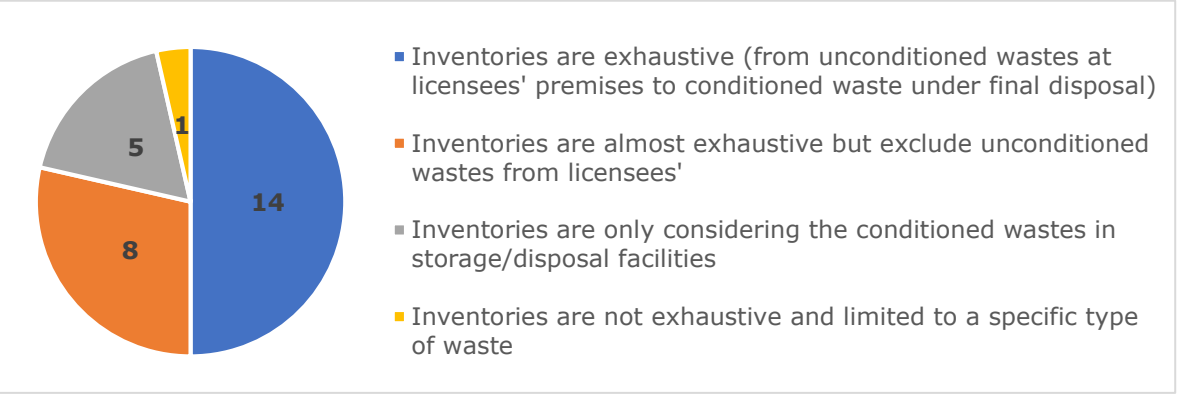


**Figure 10: Assessment per Member State of the inventories' exhaustiveness**

**Finding #10:** the inventories do not systematically include all the radioactive wastes in the management routes, for more than half of MS, unretrieved, untreated and/or unconditioned wastes are excluded. On a global scale, such approach does not generate major discrepancies in the inventories, only a delay for their consideration as radioactive wastes.

Depending on the Member States, the radioactive wastes included in the inventories do not cover the full management routes. Thus, this raises the issue of when a radioactive material should be considered as a radioactive waste and accounted as such.

All the Member States share the same approach regarding the identification of radioactive waste (*radioactive material becomes a radioactive waste at the instant where it can no longer be used and thus become a by-product*), they are accounted as such by licensees' but not systematically included in the inventories for various reasons (*complexity of evaluating the exact volume that will later on be sent to long-term disposal, impact of the different waste treatment process that will affect the waste inventory…*).

**A good practice to solve the previous issues (*lack of global vision due to the non-systematic inclusion of radioactive wastes still in the early phase of management routes, and non-consideration of radioactive materials not yet considered as radioactive wastes*) would be to extend the perimeter of inventories to radioactive wastes, spent fuel and radioactive material**. Such modification would allow a more homogeneous inventory coverage inside European Union.

### 6.1.5 Member State national inventories wastes location

Inventories are not limited to volume estimate, the Council Directive 2011/70/Euratom Art. 12 c) also requests the Member States to precisely communicate about the waste location.

For the vast majority of countries, information regarding the location of the radioactive wastes and spent fuel are systematically provided: either by pointing the waste location for each type or waste category (18), or by describing in depth the waste management facilities (storage and disposal) and the types of wastes accepted (8).

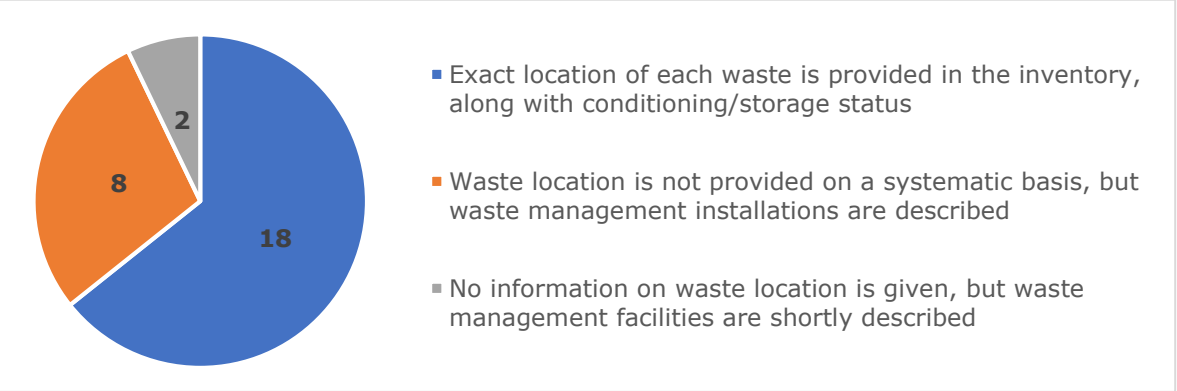


**Figure 11: Assessment per Member State of the precision of the waste location**

**Finding #11:** the information regarding the location of radioactive wastes and spent fuel in EU Member State can be found in national reports and publications. MS either directly specify the location for each identified waste family, or they describe in detail the characteristics of the waste management installations and management routes, allowing to identify the waste location based on its nature.

## 6.2 Summary of findings

Regarding the current inventories of radioactive wastes and spent fuel, the Member States often limit the published information to the specific requirements of the Council Directive 2011/70/Euratom, thus giving neither detail on the methods, tools and approaches used for the preparation of national inventories, nor on the uncertainties.

A specific survey regarding these methods/tools/approaches enabled identification of the main patterns used for the inventories' preparation. They are generally the result of self-declarative evaluation from licensees that fill and forward "databases" to the entity in charge of the inventory consolidation.

Proofreading processes are limited, no particular "back-and-forth process" is reported between licensees' and inventory responsible. Consistency of the data transmitted is checked during the inventory preparation. The frequencies of update of the inventories vary among Member States, and is often linked to the frequency at which data are collected: for MS with automatized systems (*i.e. online transmission of data*) the inventories are continuously updated and regularly published, while MS relying on periodic surveys can only update their inventories after each survey.

# 7 Future estimates for spent fuel and radioactive waste

## 7.1 Assessment of EU-28 situation

The Member States generally follow the same approach for current and future inventories, most of the findings developed previously remain applicable for future inventories.

The key challenges regarding the preparation of future inventories are:

- The uncertainties related to the mid/long-term estimates, especially the consideration of decommissioning wastes;
- The approach used to quantify future waste fluxes (*business as usual as compared to specific assessments*);
- The uncertainties regarding European nuclear programmes, with major societal challenges for renewal and/or decommissioning of nuclear power plants. The associated waste production life cycles remain uncertain.

### 7.1.1 Member State reliability of tools/approaches/methods to develop future inventories

A high precision can be expected in the preparation of current inventories, as the radioactive wastes and spent fuel to be quantified are already part of the management routes, the majority being in a situation of safe storage and/or disposal. The methods, tools and approaches are meant to support an exhaustive development of the inventory.

Regarding the future inventories, the evaluation of wastes quantities is, by definition, more uncertain, as various parameters have to be considered to draw scenarios of the potential future outcomes regarding nuclear activities and their associated radioactive wastes and spent fuel (*nuclear installations operating duration, decommissioning decision, type of decommissioning strategy, waste management strategy, national nuclear strategy for new build and decommissioning…*).

Thus, the tools/approaches/methods assessed in the frame of the section are of two different kinds:

- The ones used by stakeholders to gather "raw information" regarding the future generation of additional quantities of current radioactive wastes and spent fuel (*decommissioning scenario, assessments based on historical fluxes…*). These methods/tools/approaches shall enable stakeholders to evaluate in detail the radioactive wastes and spent fuel quantities to be generated for each application, installation… Some similarities shall be observed with the methods/tools/approaches used in the present inventories.
- The ones used by stakeholders to define scenario(s) for future inventories of new wastes or wastes arising from new activities taking into account different kinds of uncertainties (*decommissioning uncertainties, timeframe, nuclear facilities operating scenarios…*) and leading to a conservative inventory for the future. Such tools/approaches/methods are exclusive to future inventories, where it is first needed to define the context in which radioactive wastes will be generated, the future inventory being generally a combination of different scenarios.

The following figure deals with the second kind of tools/approaches/methods. The vast majority (18) of Member States provides details regarding the overall approach used for the preparation of the future inventories. The assumptions used by the Member States are generally described (*shutdown date for Nuclear Power plant, decommissioning schedule, decommissioning strategy, date of commissioning for new build and operation duration, average operational wastes produced per installation, availability of waste treatment/conditioning/storage/disposal facilities…*).

Some Member States (7) do not provide any information on the various assumptions used to build future inventories which prevents readers assessing the quality of these evaluations.

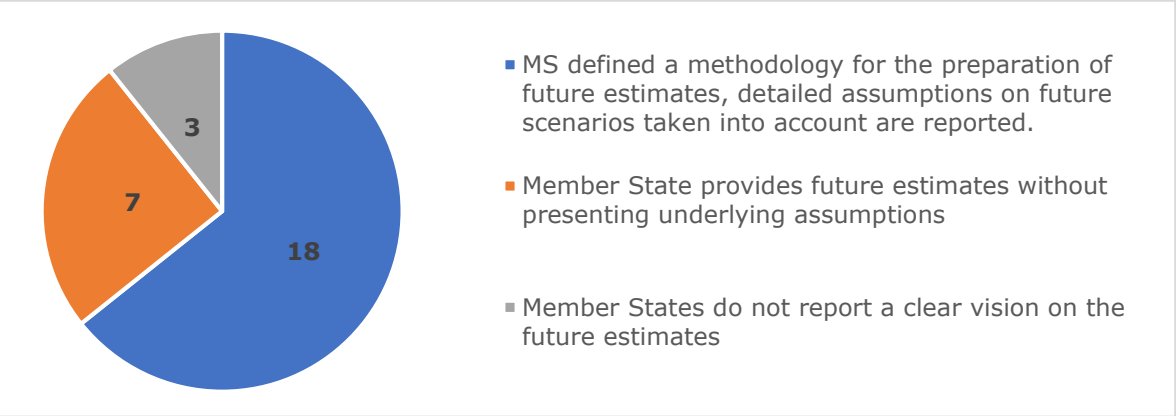


**Figure 12: Assessment per Member State of the Reliability of tools/approaches/methods to develop future inventories**

Limited information is given on the way radioactive waste volumes data are estimated or gathered. This situation is similar to the lack of information observed for approaches, tools and methods of current inventories.

Nevertheless, different approaches are used, depending on the Member States, to evaluate the future quantities of radioactive wastes and spent fuel:

- For MS with limited volumes of wastes coming from a small number of waste producers, the future wastes fluxes are generally assessed on the basis of the historical yearly waste generation. An approach "business as usual" is commonly used to estimate the future inventories at key dates.
- For MS with large volumes of wastes, specific developments are generally performed. In the case of decommissioning activities for example, the year-per-year generation of wastes estimated in the decommissioning plan can be used to assess the future wastes volumes. Average historic fluxes are often used for assessing operating wastes per installation.

A few Member States (3) do not formally have future inventories, or with very limited information. Such situation remains marginal and only concerns countries with almost no radioactive wastes (*only medical and industrial ionizing radiation activities with imported sealed sources*), they manage on a case-by-case basis the radioactive wastes in these countries.

### 7.1.2 Member State future national inventories exhaustiveness

Concerning the adequacy between the future inventories and the waste classification, Member States do not systematically structure their future inventories in line with the radioactive waste classification approach.

Situation is nevertheless better than for the present inventories, with 17 MS having future inventories fully in line with classification, with quantities given in a consistent approach, against only 12 for present inventories. Such difference being explained by the use of average historic waste generation to compute future inventories, allowing to easy extrapolation the inventory evolutions.


**Figure 13: Assessment per Member State of the exhaustiveness of future inventories according to waste classification**

### 7.1.3 Member States future national inventories perimeters

The future inventories generally include (23) all the future wastes generated within the Member State, without any restriction on the origin: conditioned/unconditioned wastes, stored/disposed wastes, wastes inside licensees' installations, decommissioning wastes…

Only a limited number of MS prepared future inventories while excluding some radioactive wastes types:

- Some MS only account the radioactive wastes to be conditioned at a given date (*excluding in this case all the radioactive wastes under temporary storage at licensees' facilities*), or only account the radioactive wastes and spent fuel already disposed in the final repositories.
- Some MS (*with very limited volumes of wastes*) focus their future assessment on the sealed sources, without considering any other sort of wastes.

NORM are currently outside of most radioactive waste inventories perimeters (*NORM have been previously discussed, see §4.1.5*), the issue of the current debate regarding the status and consideration of NORM appears as an uncertainty. Depending of the Member States positions, NORM can either be considered as resources (i.e. formally excluded from waste inventories) or future radioactive wastes to be included in future inventories.

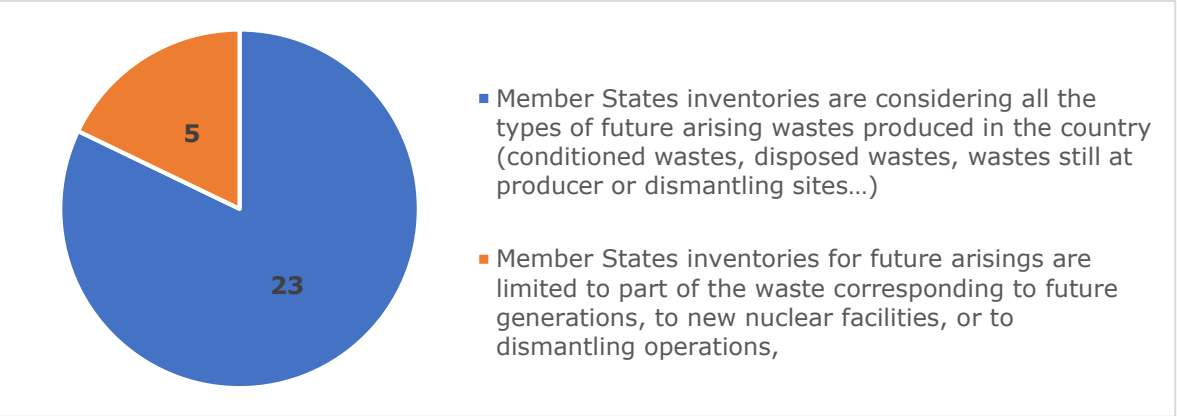


**Figure 14: Assessment per Member State of the future inventories' perimeters**

### 7.1.4 Member State future national inventories consideration of decommissioning wastes

The future decommissioning wastes have to be included in the inventories. At the EU-28 scale, almost all Member States include them when assessing the future volumes of wastes to be considered.

The good practice is shared among Member States, with limited deviations where decommissioning wastes are mentioned but not systematically included in the inventories or uncertainties remain on the inclusion of some specific installations (cyclotron dismantling, research installations…).

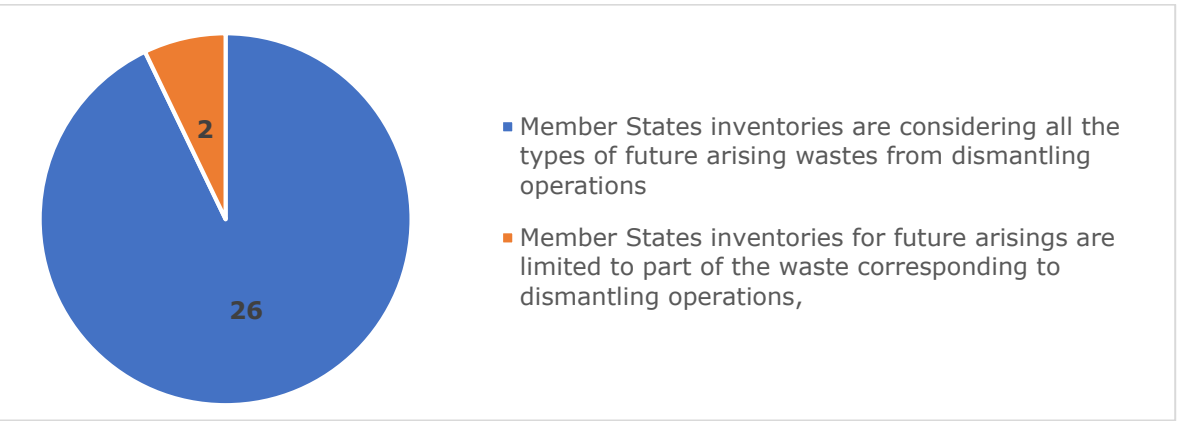


**Figure 15: Assessment per Member State of the consideration of decommissioning wastes in the future inventories**

**Finding #11:** Decommissioning wastes are almost systematically included in the future inventories of radioactive wastes.

### 7.1.5 Member State future national inventories uncertainties

The management of the uncertainties remains a crucial issue while preparing radioactive wastes and spent fuel inventories, either for current or future inventories. Current uncertainties have been previously discussed and remain mastered by licensees' and management routes stakeholders.

Regarding the uncertainties in future inventories, situation is different as a large number of parameters are directly impacting the inventories. Additional emphasis on the

potential uncertainties should be included in the inventories, to support their exhaustiveness and accuracy.

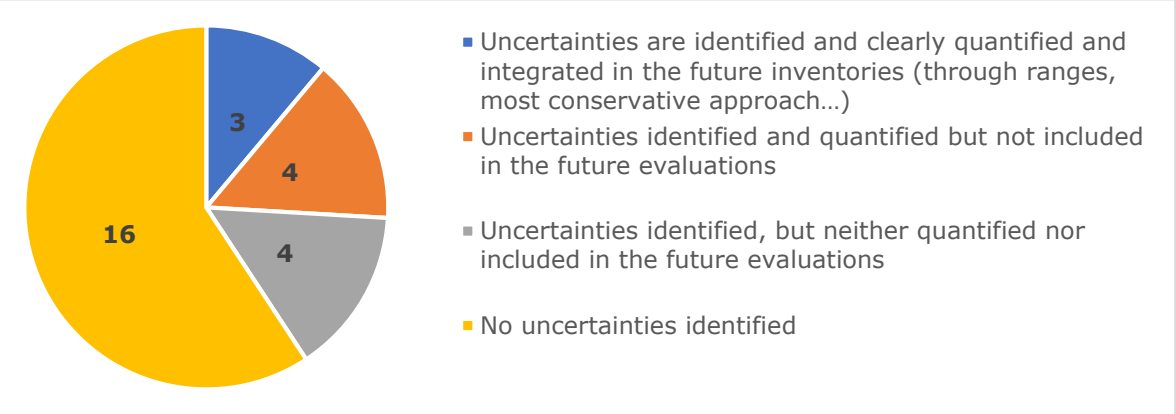


**Figure 16: Assessment per Member State of the uncertainties' integration in future inventories**

Among Member States the consideration of uncertainties in future inventories is unfortunately similar to the limited work performed in current inventories. Most of the Member States (16) do not discuss at all this issue in the national reports, neither on quantitative nor qualitative basis. Some briefly introduce this matter (4) but without providing evidence on how such uncertainties are affecting inventories, while others (4) identify uncertainties and perform aside some assessment of their impact on waste volumes but do not include them in the future inventories.

Only a few countries (3) have fully transparent methodology regarding uncertainties, from their identification to the quantification of their impact on future inventories.

### 7.1.6 Member State strategies for future national inventories displays

The preparation of future inventories is mandatory for the development of a national strategy for radioactive waste and spent fuel management, especially for assessing the needs in terms of treatment, storage and disposal installations. The approach used by Member States to display their future inventories is often linked to the main milestones expected in the country (*end of nuclear programme, commissioning of storage/disposal facility…*).

In national reports and public communications, the future inventories have varying degrees of details:

- Some Member States (7) provide in-depth description of the future inventories, with a details per installation or activity of the future fluxes, along with an inventory at different milestones dates (*every ten years, or for key events such as the commissioning of disposal facility*);
- Some Member States (8) do not provide much details on the origin of wastes but perform inventory results at different milestones. It remains difficult to assess the origin of the future wastes, and the activities on the period generating wastes. In this case, the inventories are the results of specific calculations, based on operating and decommissioning scenarios, with radioactive waste production schedules.

- Some Member States (10) only performs average estimate of yearly waste generation and use these historic average values to assess future waste generation. Such approach is consistent for Member States with limited waste volumes.
- Only a limited number of Member States (3) do not report future inventories for reasons developed previously.

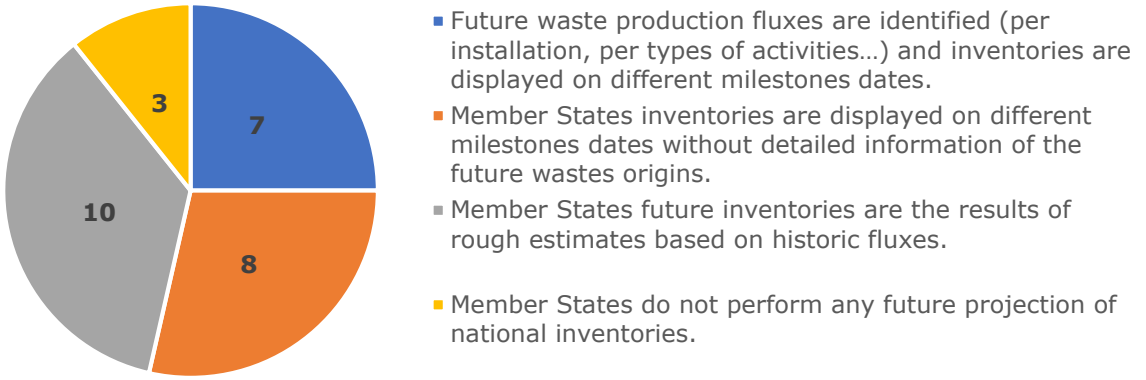


**Figure 17: Assessment per Member State of the future inventory display approach**

## 7.2 Summary of findings

The main challenges regarding future inventories are mostly linked to the uncertainties to be dealt with while assessing future waste volumes, especially in decommissioning activities where error margin can remain important.

The decommissioning wastes are systematically included in future inventories, but the consideration of uncertainties remains limited in national reports, making it difficult to conclude on the accuracy of future inventories in the absence of details regarding the data origin and calculations performed. Same situation can be observed for current inventories, where results are presented without much justification or supporting methodology.

# 8 Management system and record keeping of national inventories

## 8.1 Assessment of EU-28 situation

The methods, approaches and tools used for the preparation of national inventories directly impact the way they are published, along with the communication between stakeholders, especially the verification and feedback process with the licensees. The record keeping issue is being discussed among Member States, in line with the development, commissioning and operation of disposal facilities.

### 8.1.1 Member State update frequency of the inventories

Each Member State has its own approach regarding the preparation of radioactive waste and spent fuel inventories. The approach in use has a direct impact on the periodicity of the preparation and publication of the national inventory.

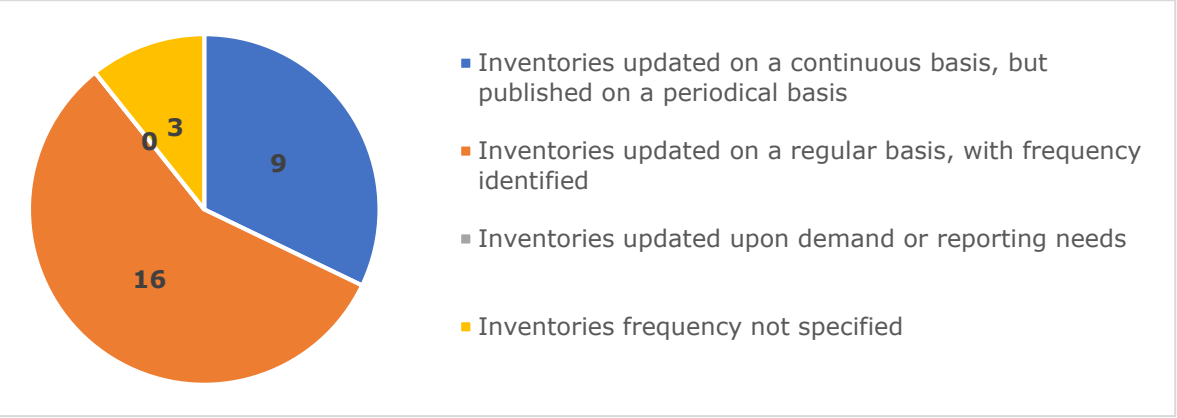


**Figure 18: Assessment per Member State of the inventories update frequency**

The state-of-the-art approach, observed in 8 MS, consists in a process of automatized data collection, updating in "real time". Information is coming directly from the licensees; no solicitations from the waste agencies are needed, the licensees send information (*when new radioactive wastes or spent fuel are generated, or conditioned, or transferred…*) to the entity in charge of waste management and inventory that updates databases. Based on the information provided by licensees, inventories can be prepared at any time and published with the needed frequency (*e.g. in France, Andra performs a real-time collection of data, and every year at the 31st December date an inventory of all the radioactive material in the country is prepared. Such work is published every three years*).

The vast majority of Member States (16) have a periodic approach for inventories: at a defined date or periodicity, the licensees communicate waste information to the entity in charge of national inventory. Usually, licensees are asked to provide once a year a situation report regarding their radioactive waste and spent fuel. Once all the information is gathered, the national inventory can be prepared and published (if needed).

The former approach observed in EU, consisting in licensees providing information only upon demand, with no national inventories performed on a systematic basis can no longer be observed.
*Nota Bene: it has been impossible to conclude on the approach used by three Member States, despite solicitations through dedicated questionnaire.*

**Finding #12:** Among Member States, data collection process is either continuous or on a regular basis. The information collected is generally sent directly by the licensees to the entity in charge of the national inventory preparation. The inventory publication does not always follow the same periodicity as the data collection.

it must be noted that Member States are also periodically reporting to the EC about national inventories in the frame of the Joint Convention.

### 8.1.2 Member State communication procedures between national waste agencies and licensees on the inventories

An efficient communication process is needed to ensure smooth exchanges of information between licensees and national waste agencies. In the case of national inventories preparation, a transparent and efficient communication process is needed to ensure the accuracy and exhaustiveness of the data transmitted.

The entity in charge of the national inventory preparation can only rely on the information transmitted by the licensees and has to put in place some contingency measures to attest the quality of the information received (audits, feedback process, verification procedure…).

A limited number of Member States (7) detail publicly the approach used to gather and verify the waste inventory inputs. Generally, the overall approach used is described, but without much details on the specificities of the verification and validation process.

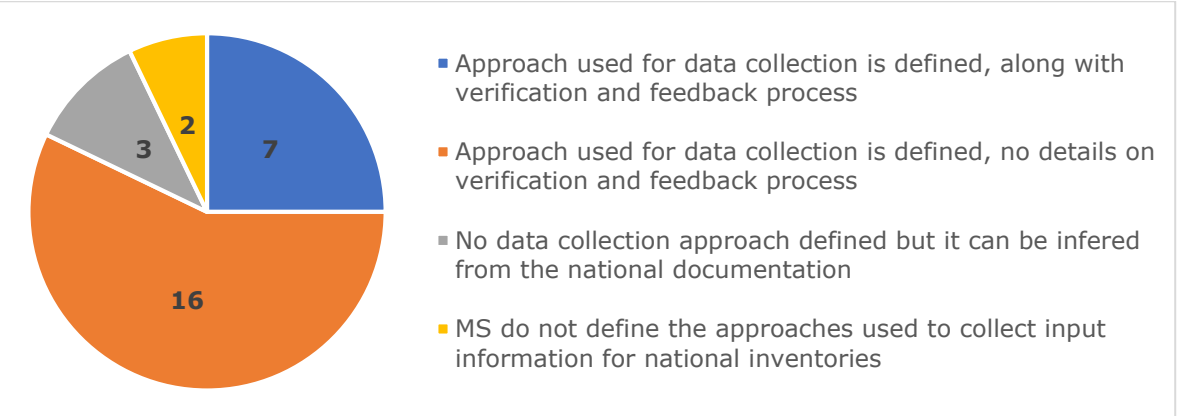


**Figure 19: Assessment per Member State of the approach used for validation and verification of the inputs transmitted by licensees**

When described, the same approach can be observed in different Member States:

- The entity in charge of the inventory establishes a reference template for waste reporting to be completed by licensees. Such templates cover the country specifics (waste classification, installations, national requirements…). The document is then distributed to licensees.

- This template has to be filled, in line with standard quality assurance requirements, under licensees' responsibility. They are either requested to fill the document on a continuous basis (i.e. database is updated after each change licensees waste quantities) or at regular date (once a year, once every two-years…).
- Upon receipt, the consistency of the information transmitted is checked by the entity in charge of the waste inventory preparation, through cross-comparisons with site authorization, licensees' strategies… In some cases, audits can be performed to check onsite how templates are filled.
- Once all the inputs have been gathered, the data collection and preparation of the inventory can start.

The whole process follows a "one-way" approach, without back and forth between the licensees and the waste inventory responsible. No additional feedback is expected from licensees once inputs have been transmitted.

The vast majority of Member States (15) briefly describes the overall approach used for the review and update of the national inventories, without describing in detail the exchanges with the licensees and their feedback. Licensees are usually required by law to communicate current and future sources, streams, quantities and characteristics of radioactive wastes and radioactive materials used in the Member States. The tracking system and site inventory is also under their responsibility.

**Finding #13:** The communication between licensees and the authorities for waste inventories management depend of the national strategy used for inventory preparation (continuous or periodic data collection). The licensees report to the authorities using specific templates or computer system, with an agreed frequency (e.g. once a year), or after any change in the current information. In most cases, no back-and-forth between the two is under use (except in case of major issue with the data transmitted).

### 8.1.3 Member State record keeping and memory keeping mechanisms

Record keeping mechanisms are under the responsibility of storage/disposal facility operators. Nowadays, inventories are prepared in electronic version (with paper format copies), and record keeping generally consist in the preservation of these databases until final closure of the storage/disposal facilities and the switch to memory keeping mechanisms. Licensees are also often expected to keep information on their radioactive wastes sent to storage/disposal facilities on a limited duration (a few years).

When they exist, memory keeping obligations are defined within the law, describing the responsibilities of licensees on short and long-term, often split between nuclear facilities and disposal facilities.

Among Member States, very few storage and disposal installations have been definitely closed (Centre de la Manche in France): near-surface disposals are under operation in various countries (*Czech Republic, Finland, France, Spain, Sweden, UK*), while deep geological disposal projects are underway in various EU Member States. Thus, the memory keeping mechanisms currently appears as an open topic, that is under development.

A first example is provided by the Centre de la Manche, where a first memory keeping experience is available. For most of the projects, technical solutions and procedures will be finalized in the next decades, with the closure of disposal facilities and the commissioning of final disposal solutions (especially deep geological disposals). Several countries are already working on various scenarios and technical solutions to ensure the inventory preservation (*data can be stored onsite, at national archive facilities, in permanent paper or electronic format, onsite permanent labelling…*).

There is currently no real best practice in this field: some Member States are already experimenting with different solutions for memory keeping, but most countries will take decisions regarding record keeping during the next decades.


**Figure 20: Assessment per Member State of the record and memory keeping mechanisms**

The analysis shows that very few Member States (7) provide in the open literature details on the approach used for record keeping mechanisms (tools, duration…). The majority of MS (11) shortly introduce the issue or make indirect references (5). In some cases (5), no information can be found on the record keeping mechanisms.

**Illustration of France developments on record and memory keeping mechanisms**

**Record keeping**

Since 2012, Andra has grouped together all information about waste packages in a single place: OSCAR (Organisation of Andra's Package Knowledge Base and Repository). Oscar is a digital library that integrates all technical data relating to the different types of waste.

This repository of quantitative and qualitative data draws information from both:

- producers, through data files such as radiological inventories, thermal power, the number of primary packages, or the description of the waste
- and Andra, through its knowledge from the design of disposal containers or knowledge acquired during monitoring work.

These elements are analysed using the agency's expertise in R&D, safety and engineering. From the most general information to the most specific, Oscar ensures there is overall consistency between all contributions and presents this information in the form of highly detailed factsheets.

The result is the centralised waste management knowledge base. Information entered into Oscar is certified as it has been checked, described using standardised language and indexed.

And because knowledge is constantly evolving, the factsheets are regularly updated by contributors from entities with knowledge of the packages. Each previous version is archived, and the latest publication updated at a time 'T' serves as a single point of reference.

A knowledge change management and data traceability tool, Oscar is part of Andra's new digital system.

All radioactive waste has to be packed respecting Andra's acceptance criteria in terms of activity, radionuclide, physical and chemical nature. For all waste packaging family, different parameters are set: a list of radionuclides, a list of physical nature, activity limits. A producer cannot declare radwaste characteristics that has not been set in the application.

Before shipping radwaste to the depository, characteristics of each waste has to be sent to Andra in a specific file. All the information sent by waste generator are computer-checked. The identification of each waste package is printed on a barcode label stuck on the waste container. This unique id of the package is also used in the declaration file.

If compaction treatment is performed on the waste, the link between the received waste and the disposed package is recorded in the database. After disposal, the location, the date of disposal… are added in the database.

**Memory keeping**

Andra is developing a wide set of provisions for each of the radioactive waste repositories they are in charge of. This set includes provisions that are required according to the French regulatory framework regarding memory keeping of the disposal facilities, plus other provisions added in order to enhance robustness and extend the duration of the preservation and transmission.

The regulatory provisions contain:
- a Summary memory file, a preliminary version of it being required when entering the closure phase. The summary memory file describes shortly the repository as built and the waste inventory, with the position of the various wastes, as well as their chemical and physical properties. An updated version is due when entering the surveillance phase.
- a Detailed memory file, due when entering the surveillance phase.

As the Manche surface repository (CSM) is the first repository operated by Andra, now in the closure phase, this facility is considered by Andra as a pilot for the memory provisions. The preliminary version of the summary memory file of the CSM was issued beginning of 2019.

The Detailed memory file will be printed on "permanent" paper in at least two copies, one of them being sent to the French national archives, and another kept at the repository. This occurred already 3 times, two for the Manche repository and one for the Aube surface repository (CSA), for subsets of the Detailed memory file.

## 8.2 Summary of findings

Over the EU-28, the standardized communication approach used between licensees and authorities appears efficient and adapted to the specificities of radioactive waste and spent fuel inventory preparation. Licensees are responsible for the accurate and exhaustive transmission of information, while authorities are in charge of compiling and preparing the national inventories.

Licensees communicate information in line with authorities' expectations (forms, template, online database…), this allows authorities to update (generally on a yearly basis) and publish inventories at the desired frequency.

The record keeping mechanisms are different for medium and long-term, and shared between licensees and disposal operators. For long-term record keeping, situation is different as most disposal facilities are not yet built, this open issue is under consideration and various possibilities are explored while long-term disposal facilities are being developed.

# 9 Recommendations

Various findings were identified along the implementation of this EU benchmarking. It is proposed to highlight the following two recommendations

**Recommendation 1**

Radioactive waste classification is used to report national inventories, but not systematically for all reported wastes. In various Member States, the reporting is done for some waste families through values used onsite *(number of sources, number of drums, number of bags…)*, without specifying the waste categories. **It is recommended to support a systematic use of the waste classifications in National reports**

**Recommendation 2**

It appears that the approaches, methods and tools used by Member States to develop National radioactive waste and spent fuel inventories are almost never developed or communicated in the public documents such as National Reports or communicated to the European Commission. Member States currently report according to Art.12 of the Directive, which does not require the reporting of the approaches, methods and tools.
It is nonetheless recognized that highlighting these aspects in National reports would be helpful to progress toward a better understanding of the reported figures.
**It is recommended that MS's take into consideration how to include in the national report, a description of approach/methods/tools used for the development of current inventories and future inventories as well. This will give a full confidence that MS's are thoroughly managing and establishing inventories (current and future) of Radioactive Waste and Spent Fuel with exhaustiveness, accuracy and uncertainties of quantities, volumes and activities.**

In the absence of a detailed framework for the preparation and publication of radioactive waste and spent fuel inventories, each Member State has adopted its own strategy. Although this benchmark study across the 28 MS's has concluded that their current inventories are well developed, it remains room for improving important aspects. It is recommended that the EC considers the development of a reference European guideline (on the model of IAEA guidelines), on how Member States should gather data, prepare inventories and communicate could lead to a better spreading of best practices that already exist in some Member States. However, RAW and Spent fuel challenges are specific to Member States waste management specificities, thus succeeding in finding a "one fit for all" approach needs to be discussed with MS's in order to find the best way and their commitment for improving the current preparation of inventories across the European Union..

Alternatively, the EC may decide that it would prefer not to propose a common methodology as this may cause difficulties for some individual member states to comply, given their situation. In this case the EC could consider developing a guideline or even requirement that each MS publishes a document to accompany each revision of the inventory which explains in detail how the MS has produced the inventory, with commentary on the process, the exchange of data between licensees and the central

inventory body, how they have considered decommissions wastes, uncertainties etc. In this way a process of "self-improvement" may be promoted.
Member states are now more open to question by its own stakeholders, the public and their peers. Therefore, there is room and opportunity for the EC to open discussion with MS by promoting this visibility of "best-practices", the EC may enable MS's to learn from others and develop a more effective process that best suits their situation.
It is noted that, in meeting with the 5 visited MS's, it was clear that the process of compilation of the inventory was better developed and more controlled than is explained by much of the published documentation. This may suggest that development of national inventories across the entire EU is better than may initially appear and may support the suggestion above that published methodology documents would be a useful contribution to both understanding and continuous improvement through exchange of best practices.

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