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IMPLEMENTATION OF SAFEGUARDS INSPECTION REGIMES IN EURATOM MEMBER STATES AND OTHER NUCLEAR COUNTRIES

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ABSTRACT

The ESARDA Implementation of Safeguards (IS) Working Group (WG) conducted early 2021 an analysis of the different safeguards inspection models that are applied in Euratom Member States and in other nuclear countries in order to underline the most important existing trends in the different safeguards inspection regimes. To perform this analysis, the group elaborated as a first step a questionnaire with 17 questions, widely distributed to representatives of regulatory bodies responsible for safeguards matters. Thirteen responses have been received so far, from the following countries: Belgium, Czech Republic, Finland, France, Hungary, Ireland, Japan, Latvia, Norway, Slovakia, Slovenia, Sweden and Switzerland. This paper provides a first general overview of the different existing inspection regimes and the associated trends based on the analysis of the responses supplied in the completed questionnaires. As an introduction, the different types of safeguards agreements and other legal binding texts related to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) that are in place in each country involved in the study are presented. The paper then focuses on the description of the large variety of nuclear facilities, location outside facilities and nuclear activities present in these countries and for which specific international and national control provisions exist. On this basis, an overview of the different kinds of safeguards field activities performed by the International Atomic Energy Agency, Euratom and/or by the national competent authorities for NPT related matters is provided. This overview also includes figures associating the intensity of the verification activities, including the number of inspections, to the type of nuclear facilities, location outside facilities and nuclear activities. Finally, this paper describes the main trends and observations identified in terms of safeguards inspection regimes. The compiled information in this paper will allow ESARDA's IS WG to set up a basis for possible further studies on some identified trends.

INTRODUCTION

The ESARDA Implementation of Safeguards (IS) Working Group (WG) aims to provide the Safeguards Community with proposals and expert advice on the implementation of safeguards concepts, methodologies and approaches aiming at enhancing the effectiveness and efficiency of safeguards on all levels, and serves as a forum for exchange of information and experiences on safeguards implementation.

This working group developed a questionnaire with the objective of gathering information on the different safeguards inspection models applied in Euratom Member States and other nuclear countries, and to identify trends or significant differences in the way safeguards inspections are carried out.

The process applied for identifying potential countries to participate in this work was first to contact the members of the ESARDA IS WG's representatives of regulatory bodies in each country in June 2020. As a second step, and in order to broaden the range of possible responses, representatives of authorities outside this group were contacted in September 2020.

The questionnaire sent out contained an introduction, followed by 17 questions to fill in, including tables of figures expecting data from 2017 to 2019. In order to highlight the most up-to-date data, the 2019 figures are primarily presented in the text below.

Thirteen countries responded to the questionnaire: ten Euratom Member States (Belgium, Finland, France, Hungary, Ireland, Latvia, Czech Republic, Slovakia, Slovenia and Sweden) and three non-Euratom countries (Japan, Norway and Switzerland).

The text below is based on these responses received and attempts to remain consistent with the comments provided. Overall, almost all questions were answered, although there were some discrepancies in the way the tables were filled in (e.g. sometimes for a specific question they were filled-in per facility, some other time per site, or per entity). It was sometimes necessary to crosscheck the answers to several questions in order to better understand the answers.

SAFEGUARDS REGIME AND NATIONAL IMPLEMENTATION

The safeguards agreements that are in place in these countries are fairly uniform. Almost all of them have comprehensive safeguards agreements (INFCIRC/193 for the European Union (EU) and INFCIRC/255, INFCIRC/264 and INFCIRC/177 respectively for Japan, Switzerland and Norway) supplemented by an Additional Protocol. The only special case is France, which has made a voluntary offer safeguards agreement (INFCIRC/290), also with an Additional Protocol.

Two situations are identified with regard to national implementation of safeguards activities:

- Most of the countries (Finland, Hungary, Czech Republic, Slovakia, Sweden, Japan, Norway and Switzerland) have national regulatory bodies with safeguards inspectors performing national safeguards inspections;
- Others (Belgium, France, Latvia, Slovenia and Ireland) did not establish a team of national safeguards inspectors specifically dedicated to safeguards verification, but rather have an interface to facilitate relations between international inspectors and operators, with national inspectors or regulators' representatives sometimes accompanying the international inspections.

TYPES OF NUCLEAR FACILITIES

Before getting to the heart of the matter, it is important to mention that when processing the answers to the questionnaire, some discrepancies were observed in the understanding of the notion of nuclear facility, while in the framework of the delivered questionnaire a facility is understood as the smallest unit having one coherent research/industry activity. To illustrate the problematic, the case of the nuclear power plants can be mentioned: in a nuclear power station with several nuclear power plants, the facility has sometimes been understood as the whole nuclear power station site whereas in the spirit of the questionnaire authors, each nuclear power reactor and its associated structures is considered as a facility.

The authors took into account this problematic and did their utmost to present the data on a coherent basis while keeping in mind that the presentation of some results presented in figure 1 can slightly depend on the interpretation of the notion of nuclear facility in this specific case.

The number of Material Balance Areas (MBA) relating to nuclear facilities is also presented by country, also because this is the usual unit used for safeguards purposes (nuclear material accountancy, physical tracking, etc…) (see Figure 2).

Among the countries concerned, there is a wide range of nuclear facilities, location outside facilities (LOF), and locations within Catch-All-MBAs (CAM). Some countries have few or no nuclear facilities while others have a very extensive nuclear fuel cycle. Not surprisingly, among the responding countries, France and Japan have the largest number of facilities and other locations where nuclear material is used. The most represented type of location under safeguards corresponds to places within LOFs: among a total of 1200 locations, there are more than 850 locations which are not facilities. This reflects clearly the importance of a diffuse use of nuclear material.

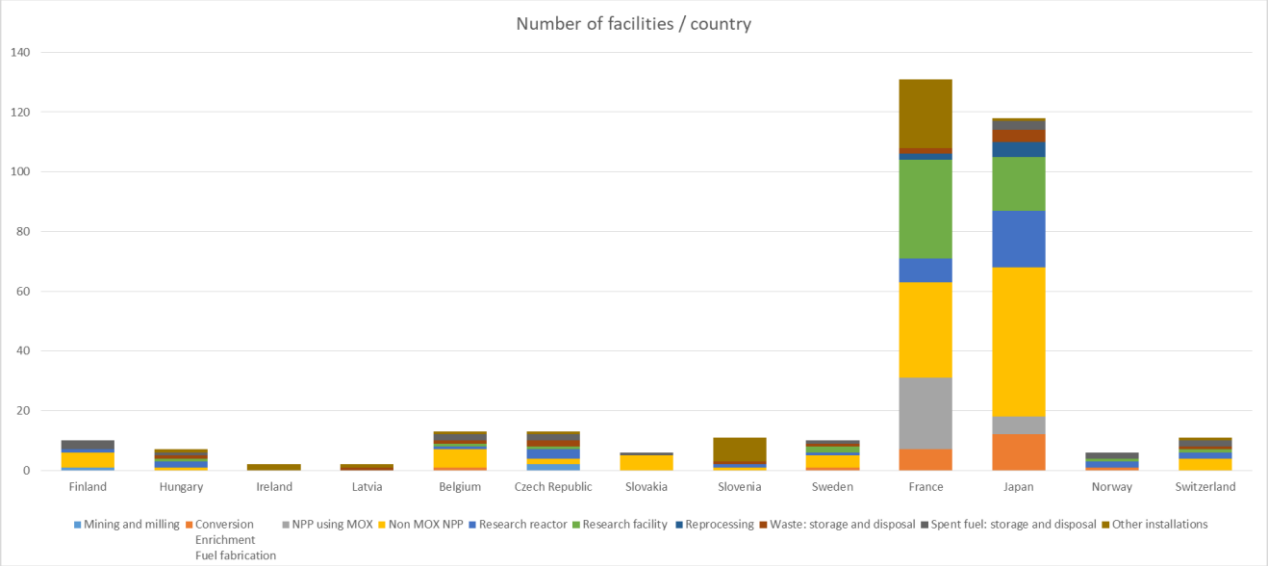

Figure 1. Number of facilities presented by country and then by type.

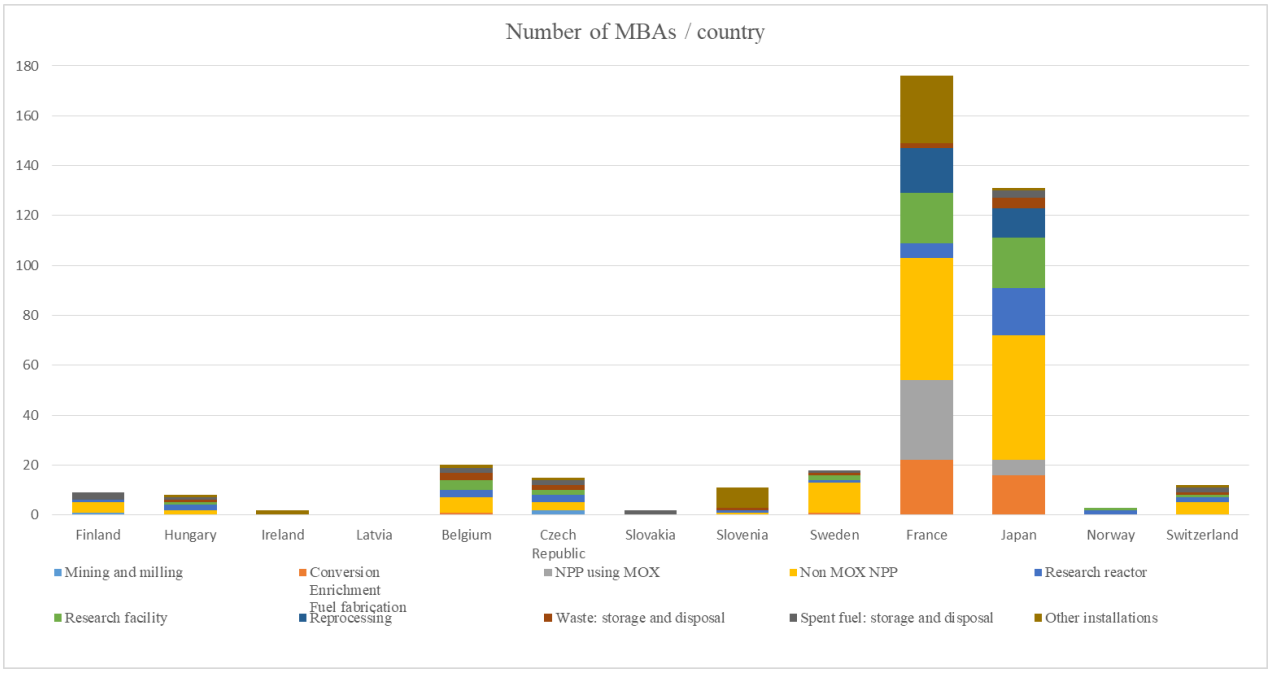

Figure 2. Number of MBAs presented by country and then by type.

For the specific case of Belgium, it was indicated that their only fuel fabrication plant has been shut down and is currently under decommissioning. The decommissioning status should be stated in 2021.

Next, among nuclear facilities, power reactors and research facilities are the most numerous (see Figure 3).

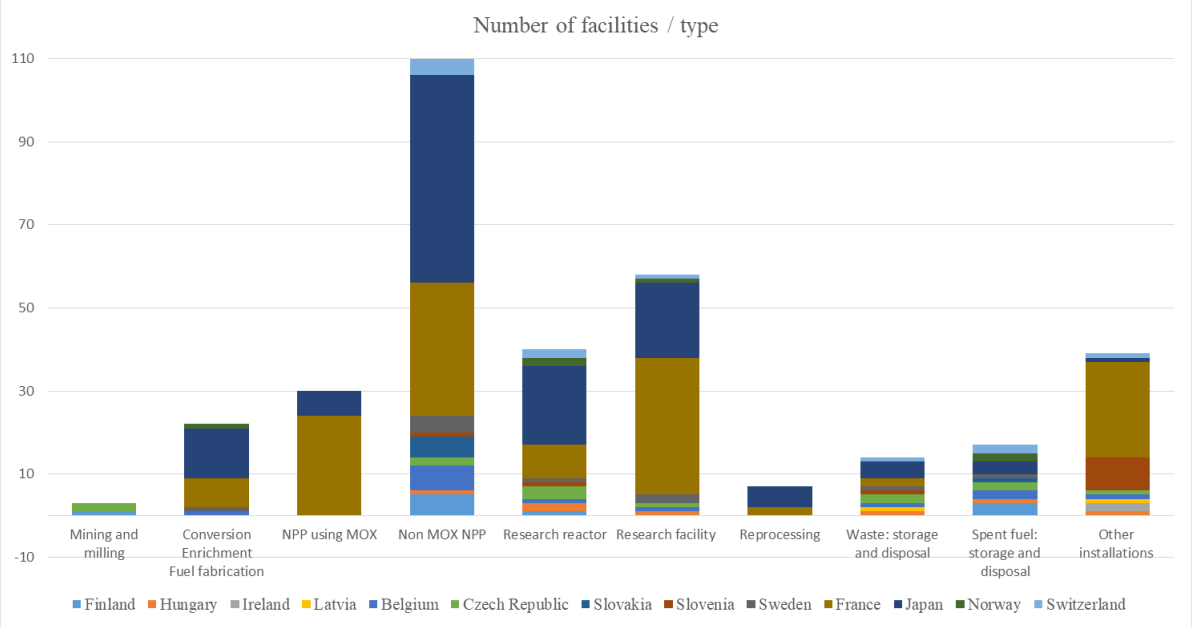

Figure 3. Number of facilities presented by type and then by country.

INSPECTION ACTIVITIES

Numbers and efforts of inspections

International inspections

As a preliminary remark, it is important to mention that data concerning nuclear LOFs and non-nuclear LOFs are here presented as they were in the national answers. A further analysis may be conducted to be sure that these LOFs have been categorized under nuclear and non-nuclear in the same way by each country, answering doubts raised by some data.

The two countries with the largest total number of international inspections (including IAEA only inspections, Euratom only inspections and joint IAEA/Euratom inspections) and the largest inspection efforts are Japan and France (see Figure 4). From our analysis, this is mainly due to the large number of nuclear facilities and the extent of the nuclear fuel cycle in these two countries.

Japan and France are followed, in terms of number of international inspections in 2019, in decreasing order, by Belgium, Switzerland, Czech Republic, Sweden, Slovakia, Hungary and Finland, which seems to match the idea that the larger scales of nuclear industry involve naturally more inspections efforts. Inferences between the scales of the industries and the number of inspections could be subsequently studied by the IS WG for this last subset of countries.

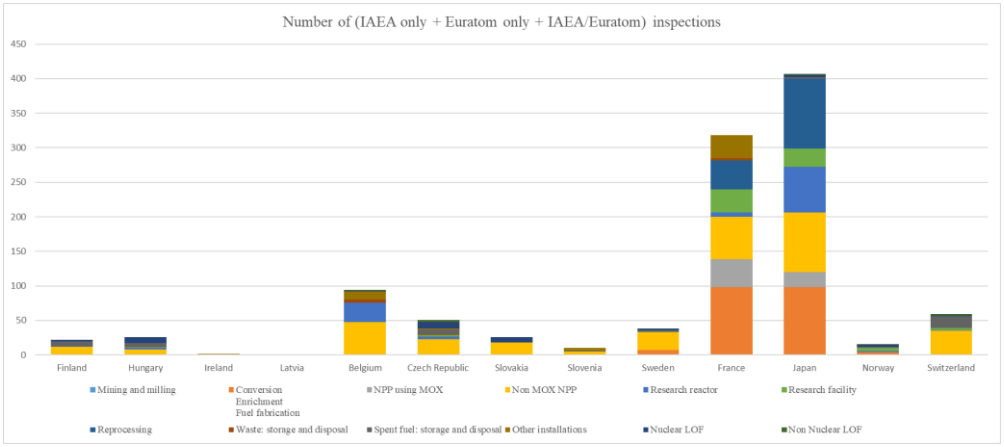

Figure 4. Number of international inspections expressed by country and then by type of facility (IAEA only + Euratom only + IAEA/Euratom jointly) in 2019.

Taking into account the inspection efforts expressed in Person-Days of Inspection (PDI) and not only the number of inspections, we can see more clearly that a big portion of safeguards efforts is concentrated on the same types of facilities for the countries involved in our study: conversion/enrichment/fuel fabrication and reprocessing, as illustrated in Figure 5.

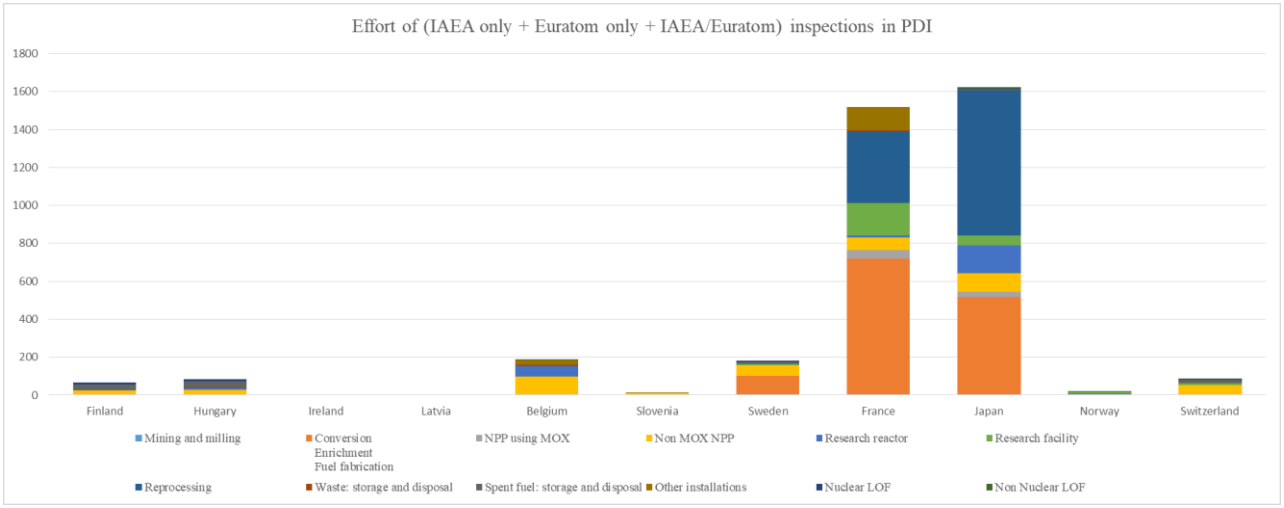

Figure 5. Inspection efforts by country and then by type of facility expressed in terms of PDI in 2019 (data non available for Slovakia and Czech Republic).

For the specific case of Belgium, it was mentioned that the inspection numbers and PDIs presented in figures 4 and 5 were counted jointly for the nuclear power plants (NPPs) and the spent fuel storage facilities as they are located on the NPPs sites. Similarly, the numbers provided for the research reactors are including also those relating to research facility MBAs as they are located on the same site. Numbers relating to the research centre in Geel were not provided as this facility is operated by the European Commission's Joint Research Centre. This remark is also applicable for figure 6.

IAEA only inspections

Some differences were observed between the numbers of inspections obtained in the answers of the questionnaire and the numbers of inspections presented in the Safeguards Implementation Report. This could be further studied in the future, it can however already be mentioned that the differences in terms of numbers could be explained by the way the counting is performed.

Japan, as a non-EU country, is only submitted to IAEA inspections (around 400 inspections/year[1]), and Switzerland to a lesser extent (around 60 inspections/year).
Unsurprisingly, the numbers of IAEA inspections performed without the presence of Euratom inspectors in the Member States countries of the Euratom Treaty are very low, the presence of Euratom being the standard.
An additional analysis could be conducted in the future, based on the "IAEA only inspections plus the joint IAEA/Euratom inspections" numbers, to compare the IAEA safeguards inspection efforts made in Euratom Member States countries with the efforts made in other countries. This analysis could help to subsequently identify general trends relating to IAEA activities and maybe relating specifically to the synergetic influence of the Euratom safeguards regime on the IAEA safeguards regimes.

IAEA/Euratom inspections
In the framework of the inspections carried out by Euratom in the countries of the EU, the vast majority correspond to joint IAEA-Euratom inspections (see Figure 6). In this respect, Euratom must even be considered in certain countries also as the representative of the State with regard to the Agency; whereas Euratom is also present during these joint verification activities to draft its own independent conclusions.
Considering only the inspections carried out by the IAEA and Euratom jointly, Belgium hosts the largest number of inspections, followed by the Czech Republic, Sweden, France and Finland (see Figure 6).

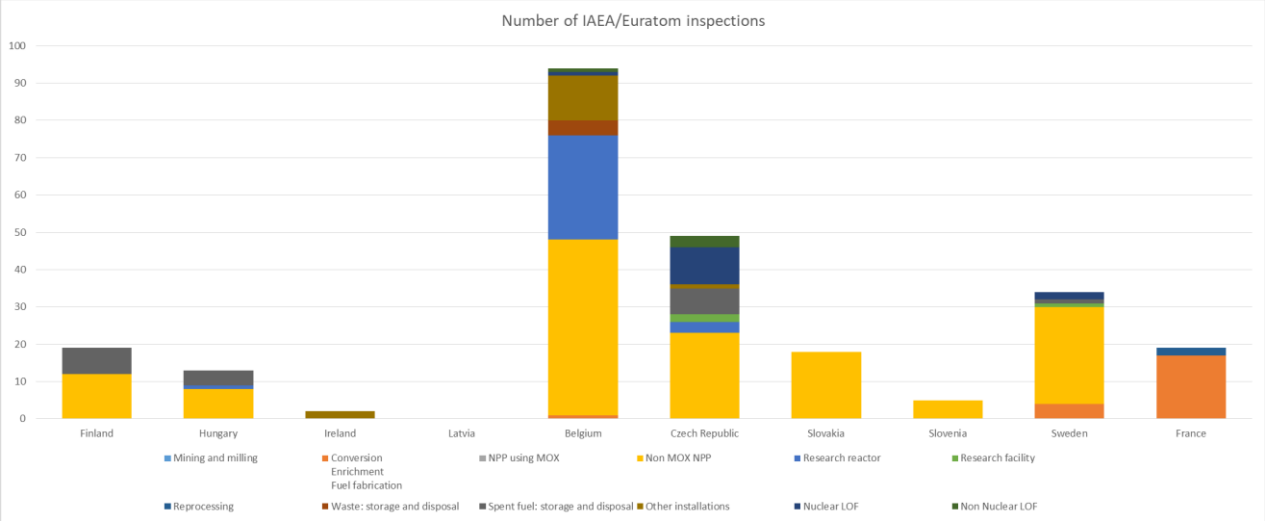

Figure 6. Number of joint IAEA/Euratom inspections by country and type of facility in 2019.

The types of facilities that are most inspected is then considered. It turns out that the majority of IAEA/Euratom inspections focus on power reactors. This can be justified by the high percentage of this type of facilities in relation to the total number of facilities covered by the study.

Euratom only inspections
There are very few countries where Euratom carries out inspections without the presence of IAEA, hence these Euratom only inspections remain very marginal, with the exception of France. This particularity can be explained here again by its status of a nuclear weapon state: the presences and activities of Euratom inspectors are the result of requirements derived from Euratom Treaty and European regulation and not from the Agency's activities carried out in application of the obligations of the Non-Proliferation Treaty.
Therefore, France is submitted to many more Euratom only inspections (around 300 inspections/year) than inspections with the presence of IAEA (around 20 inspections/year for IAEA only and IAEA/Euratom in joint team). As France is the EU country with the most extensive fuel cycle and the largest number of

[1] 279 inspections in 2019 according to "The Safeguards Implementation Report for 2019", IAEA Board of Governors GOV/2020/9 (29 April 2020), Appendix II, Table II.3.

facilities, the number of international inspections and the associated efforts are significantly higher than what is observed for other EU countries.
However, even considering the ratio of the number of inspections performed by Euratom without the presence of IAEA to the number of facilities, France remains the most inspected country by Euratom only (excluding the joint IAEA/Euratom inspections), far ahead of the other countries, explained here again by its status of a nuclear weapon state; this concerns in particular its conversion/enrichment/fuel fabrication and reprocessing facilities.
It should be highlighted that for all the EU countries, the number of Euratom inspections should be considered in relation to the total number of Euratom plus joint IAEA Euratom inspections; this analysis will be provided later.

National inspections
In addition to IAEA and/or Euratom inspections, as mentioned above, some countries have set up a national inspectorate, part of the nuclear regulatory body taskforces, that also carries out safeguards inspections. The countries that carry out the largest number of national inspections are Finland and the Czech Republic in the first place, followed by Hungary, Slovakia and Norway with equivalent figures. It is worth noting that France, Belgium, Latvia and Sweden did not have any in 2019 (see Figure 7).
Indeed, France, Belgium and Latvia did not establish a national safeguards inspectorate. However, Euratom inspections may be accompanied by representatives of the State: such accompaniment was almost systematic in Belgium in the past (in 2019 the inspections are accompanied only when specific unusual activities have to be performed) and is frequent in France and Slovenia. Sweden and Switzerland have a corps of national inspectors who systematically accompany the international inspectors.

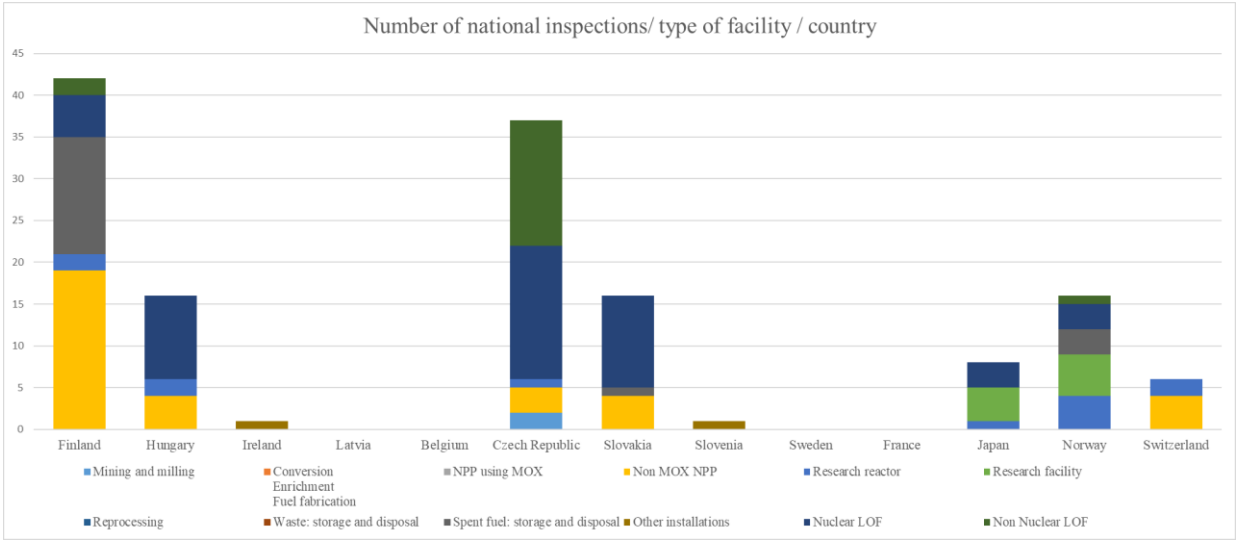

Figure 7. Number of national inspections per country and per type of facility in 2019.

Evolution of the inspection numbers in EU countries
As also shown in figure 8, most responding countries have not observed significant recent changes in the number of inspections and inspection efforts. The numbers presented in figure 8 consider only the joint IAEA/Euratom inspections.
However, Sweden reported an increase in the number of LOF inspections. Finland also points out that the introduction of unannounced inspections (UI) and short-notice random inspections (SNRI) has resulted in a decrease in the number of inspections conducted jointly by the IAEA and Euratom.
Only France notes the stabilisation of the number of Euratom inspections after a significant increase over the last ten years. In particular, since the implementation of UI performed by Euratom only for the reactors of EDF's nuclear power plants (in 2013), the inspection effort has increased by about 60% on these reactors.

The opposite phenomenon is reported by Belgium, where the total number of inspections has decreased on all MBAs concerned by the introduction of pilot UIs in 2016-2017. In 2017 and 2018, the number of inspections performed did not change significantly but an increase was observed in 2019. This could be due to the numerous new nuclear and safeguards related projects ongoing in Belgium at this moment and still under conduction following the national regulatory body involved in safeguards matters and to a higher intensity of nuclear transfers and activities. Indeed, these projects may lead temporarily to an increase in terms of inspection activities.
This number of inspections has slightly increased in the Czech Republic between 2017 and 2019, but the Czech Republic confirms in its reply to the questionnaire that this evolution is not significant.
One may wonder about the consistency of the evolution of the inspection effort in the context of the introduction of UIs: the introduction of UIs has led to a decrease in the total number of inspections in Belgium (the increase in 2019 is explained by the other abovementioned factors) and Finland, whereas the opposite phenomenon seems to be observed in France, while noting that IAEA UIs inspections and EC UIs inspections do not derive exactly from the same spirit. This could be further studied in the future.

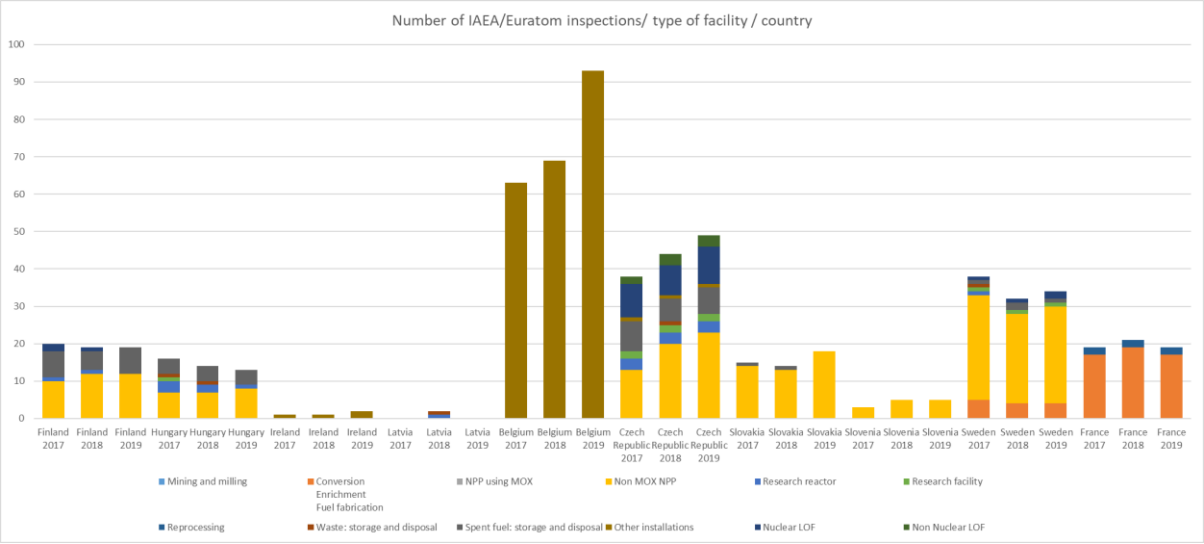

Figure 8. Number of IAEA/Euratom joint inspections by country and type of facility between 2017 and 2019 (Data by type of facility not available for Belgium).

Inspection type

Naturally, all countries under consideration are submitted to design information verification (DIV) activities, and physical inventory verification (PIV) inspections. The DIV are realised taking into account as baseline documentation for each facility the design inventory questionnaire (DIQ), also called basic technical characteristics (BTC) in countries submitted to the Euratom regime. It was noted that only six countries have core inspections.
With regard to UIs, this type of inspection concerns almost all countries, only Japan indicated that it did not have any (apart from limited frequency unannounced access - LFUAs). It would be interesting to study the reasons of the Japanese situation, before starting a reflexion on the EU countries situation.
Only France and Japan report having LFUAs, as they are the only countries involved in our study to have gas centrifuge uranium enrichment plants.
With respect to SNRIs, almost all countries reported that they were subject to this type of inspection (Finland, Hungary, Ireland, Belgium, Czech Republic, Sweden, France and Norway). It should be emphasised that through the study, it was not possible to identify a logical pattern in the implementation of SNRIs and UIs and the consequences of their implementation on the inspection efforts. A complementary study that would have the purpose of identifying potential objective factors behind these differences could be performed in the future.
Concerning the management of complementary accesses (CA), three cases can be identified:

- Euratom systematically accompanies the IAEA during CAs (cases of Hungary, Ireland, Latvia and Belgium);
- Euratom may or may not be present with the IAEA during CAs (cases of the Czech Republic, Finland, Slovenia and Sweden);
- Euratom is not present during CAs (cases of France, where Euratom is not present, and Slovakia which did not mention the presence of Euratom during CAs).

These differences can be also explained by the fact that for some countries, Euratom has the role of preferred direct interlocutor of the IAEA, in particular in the absence of a national safeguards inspectorate or dedicated interface.
Conduction of CAs and trends related to this Additional Protocol tool could be further studied by the ESARDA IS WG in the future.

Tools used for inspections

Remote data transmission (RDT) tools

Remote data transmission tools are in place for non-MOX reactor type facilities in all countries except for Belgium, France and Japan. However, such tools are used in Japan in most of its nuclear fuel cycle, except for its non-MOX nuclear reactors and its waste and spent fuel storage facilities.
These RDT tools are currently being deployed in some countries (to be implemented in 2021 for certain facilities in Belgium, currently being tested in France at La Hague reprocessing facility). This technology enables operators to reduce their constraints, in particular by reducing the time spent on site by inspectors and by reducing the number of physical inspections to be conducted, it can therefore contribute to improve safeguards effectiveness and efficiency.
Belgium is implementing several RDT tools in 2021. It would be useful to analyse if this will lead to an evolution of the number/effort of inspections in the future.
The deployment of these tools requires consideration for the benefits of these technologies (reduced inspection effort, fewer trips, etc.) and the associated risks or difficulties (e.g. cyber security).

Information systems and specific infrastructures (IT systems)

The IAEA and Euratom installed in certain facilities specific equipment for measuring or feeding back operating data from the operator or specific information systems for collecting and processing data.
The analysis of the data obtained from the questionnaire shows that the concept of IT systems may not be shared by all the answering countries. More specific questions on this matter may be necessary to detail the data.
France has such equipment mainly for fuel fabrication and reprocessing facilities. One example is the EC server at the enrichment facility of the Georges Besse II in France.
Although it is not yet possible to determine whether there is a link between the installation of such equipment and an influence on the number of inspections/efforts, it would be interesting to see whether such a link exists.

Results of inspections

Inspectors usually provide inspection results by letter; letters from the IAEA are sometimes transmitted through Euratom, when Euratom is the main interlocutor between the country and the IAEA. These results are passed on to the country's competent safeguards authority, which then forwards them to the operator, but the operator may be informed directly by the IAEA or Euratom by copy.
Most of the responding countries have no comments to make on a possible recent evolution of these practices. Three countries explicitly stated that there were no changes, while France noted an increase in the number of remarks in the post-inspection letters sent by Euratom, with sometimes the perception of a lack of consistency in the requests made between the different nuclear sites.

CONCLUSIONS

The analysis of the thirteen questionnaires allowed the ESARDA IS WG to gather substantial information on the inspection regimes applied in many countries, the majority of them being EU countries. Unsurprisingly, tools, concepts and methods seem to be applied by IAEA and EC following a coherent general basis though it was not always possible in the framework of this study to identify implementation patterns when comparing the situations between the involved countries for all implementation tools and concepts (e.g. relating to UIs and SNRIs). Further studies could be performed to identify these potential patterns that could be relating to the types of existing nuclear facilities, the nuclear material used, but also to the fact that IAEA and EC have different safeguards objectives to achieve even if they share an important interface. The influence of the last State Level Approach updates could also be studied to better understand the schemes associated to IAEA activities. These future studies however will need to rely on numbers established following a stronger and more coherent basis as some discrepancies were identified in the way states answered to some of the questions drafted by the authors of this paper. In this regard, contributions from IAEA and EC could be very valuable.

The provided data did not show any global major or sudden changes in the implementation of safeguards and there is no general or global trend towards a strong variation in inspection efforts and practices over the last years even if slight to moderate modifications were noted in some countries which seems to be associated to changes in the nuclear industry and to changes in the safeguards approaches (with the use of new tools and concepts). In this perspective, some variations in inspection efforts associated to specific types of MBAs and other locations mentioned by Sweden, Belgium and France could be underlined. Although they may sometimes correspond to changes in the situation, such as the shutdown or setting up of certain facilities and practices, or the introduction of new safeguards tools and concepts, for some specific subjects (e.g. number of inspections performed on LOFs), it was difficult however to determine what were the coherent rationales behind the observed changes; this could be further studied in the future. On this matter also, about Euratom inspections in France, it was specifically mentioned that there is a seeming lack of correlation between the introduction of new equipment or new types of inspections (UI or SNRI for example) and an increase of inspection efforts whereas a decrease might have seemed logical following the French regulatory authority. This element could also be further investigated.

In summary, this first analysis showed that there is a great diversity of situations and regimes in the countries that responded but also a general common basis. Thanks to this, it was also possible to identify sub-themes to be addressed by the ESARDA IS WG in the future. Further studies, also including input from other countries in order to enlarge the sample, could be performed to identify the aforementioned potential patterns and to better understand them. This will be possible also by proceeding to specific sub-analysis that could further target specific types of countries (e.g. Nuclear Weapon States, Non-Nuclear Weapon States, Euratom countries, other countries than Euratom countries, …), specific facilities and locations (e.g. nuclear power plants, fuel fabrication plants, wastes facilities, LOFs including CAMs …) and specific activities (UIs, SNRIs, inspections relating to cask loadings and transfers, …). The current study is thus seen as a first one that will be followed in the future by others in the framework of the ESARDA IS WG mandate.

ACKNOWLEDGEMENTS

The chairman and the project managers of the ESARDA IS WG that worked on the questionnaire about the implementation of safeguards inspection regime warmly thank all representatives from EU member states and non-EU countries that gave their time to take part in this work.
The ESARDA IS WG is very grateful to IRSN for its accurate analysis of the thirteen questionnaires and for preparing the responses in the form of a synthetic and detailed text and figures summarizing the situations in the different countries.