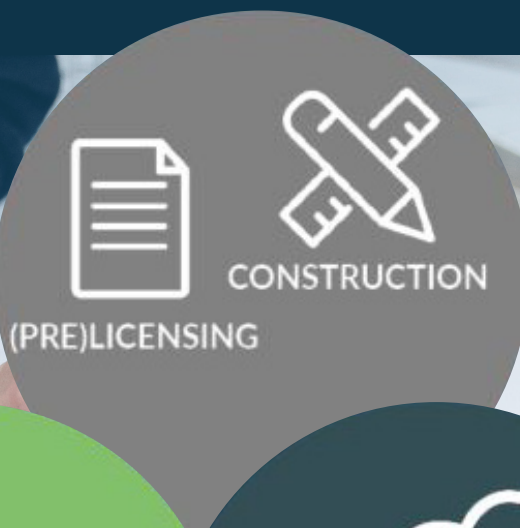


Finnish & Belgian experiences  
on contributing to peaceful use  
of nuclear material during the  
entire facility lifecycle



# Safeguards by Design

White paper

**Safeguards by Design** (SbD) is commonly understood as an approach whereby early consideration of international safeguards is included in the (pre-)design process of a nuclear facility or of a change within an existing nuclear facility, or of wherever safeguards considerations have to be taken into account during the construction, the operation and also the decommissioning phases. It is considered that it allows informed design choices that are the optimum confluence of economic, operational, safety and security factors, and of course of international safeguards.

In this framework, as the authors of this White Paper consider that the feedback generated from case studies can bring benefits to everyone, they are willing to share their experiences, points of view and reflections on the SbD implementation, hoping it will contribute to launch international cooperation initiatives towards the SbD approach in a continuous improvement vision.

In this regard, the Finnish Radiation and Nuclear Safety Authority (STUK) and Belgium's Federal Agency for Nuclear Control (FANC) have gained extensive knowledge of safeguards implementation in nuclear newbuild, plant modification and decommissioning projects over the past decades. They have independently observed the issues related to the traditional implementation of safeguards and the benefits of the SbD approach and they are also aware that existing improvement ways still exist, and that they need to be explored.

Since many years, STUK and FANC share a common interest in developing more efficient ways to adopt nuclear material accountancy and control measures, and other safeguards related matters during newbuild and plant modification projects. Carrying out a reflection on safeguards provisions and needs during the (pre-)design phases while considering the whole lifecycle of the facility eventually enables a better integration of safety, security and safeguards (3S). This also ensures that plant decommissioning and spent fuel disposal can be accomplished with no or few open questions on safeguards remaining. In this context, as nuclear regulatory bodies, STUK and FANC are determined to contribute by their own means to the general knowledge about the SbD. Therefore, we decided to collaborate on this matter by organising a virtual workshop in April 2021, in order to exchange experiences on the implementation of safeguards, and especially on the SbD.

Given the high success we achieved, we think that continuing to develop this collaboration is necessary in a way that it could be beneficial for spreading knowledge of SbD in the whole nuclear community. We are then willing to further increase international awareness of the SbD, to share our experiences and good practices, and to work together in an international framework.

## Improvements of Safeguards implementation

STUK and FANC supervise that projects are carried out strictly in accordance with nuclear legislation and regulations relating to the 3S. Operators in Finland and Belgium have successfully contributed to the building and continuous developing of nuclear material accounting and control systems to fulfil their reporting obligations. Experiences in Finland and Belgium have shown, however, that:

- (1) looking at nuclear material accounting and control measures only as provisions and measures to add to existing facilities as the consequence of necessary arrangements to adhere to, instead of as parts of a very design feature of the facility, and
- (2) starting safeguards by simply adhering to the time limits for submitting design information to the IAEA and European Commission, do not ensure an optimal implementation of safeguards at the facility.

In the European Union countries, operators of major facilities shall submit preliminary design information of their nuclear related projects to the Commission at least 200 days before the constructions of the concerned facilities begin and the design information at least 200 days before the first consignments of nuclear material are due to be received. In addition, changes in design information, such as plant modifications or preparing for decommissioning, are generally reported after the decision of their implementation has been made. Although such time limits generally allow nuclear material accounting and control systems to be started or adjusted in time, in the "traditional approach" of safeguards implementation, control of nuclear material considerations enters the facility concept at a phase where most design solutions have already been decided or construction may even have been started. Therefore, safeguards remain separate from the comprehensive facility design.

In these cases, each containment and surveillance solution for nuclear material has to be fitted into the existing design and already-built structures and the safeguards strategies may be limited as modifications of the design to better address safeguards needs are not always obvious. Furthermore, the synergies between safety, security and safeguards are then not promoted at their highest level following the shared vision of STUK and FANC. Examples of synergies to address properly would be, for the security-safeguards interfaces, the minimisation of transfer routes and diversion paths for nuclear material and, for safety-safeguards interfaces, the physical separation of safeguards equipment from other plant systems. Furthermore, should the facility design be tweaked during planning due to safety or security considerations, the tailored safeguards solutions may not be compatible with the new design solutions. Problems of late introduction of safeguards apply similarly to plant modifications and decommissioning, as safeguards involve processes that continue throughout the whole existence of the facility, including during the end-of-life phase.

In that respect and following our shared vision, without SbD considerations, there is no sufficient motivation or obligation to introduce safeguards in the facility planning, design or construction phases. Therefore, any safeguards equipment to be installed, such as cameras or sealing, usually involves retrofitting, which is expensive, difficult and prone to causing delays. In extreme cases, safeguards involved retrofitting work can hold up the start-up of a reactor or the commissioning of a plant modification. Practical examples of

consequences of late consideration of safeguards include seals in hard-to-reach places and difficulties in implementing remote data transmission due to strict IT security requirements in the Olkiluoto 3 project in Finland. In Belgium, a specific case for which SbD spirit and considerations were not applied during the operational phase of a fuel fabrication plant involved MUFs and CuMUF more difficult to justify at the end of the decommissioning phase. At that time, the FANC safeguards experts were reminded once again of how important it is to take into account the SbD approach for the whole lifecycle of a facility.

## Benefits and added values of good SbD concept and provisions implementation

Key steps include early initiation of communication by the facility operator or licensee towards the national regulatory authority and the IAEA (and the regional regulatory authority depending on the country), and inclusion of nuclear material safeguards requirements in the procurement and (pre-) design processes of the facility or of the facility modification. The former, legally mandated in Finland and informally mandated in Belgium, will allow the authorities to communicate general requirements to the licensee. The latter, on the other hand, will ensure that knowledge of the safeguards needs and requirements is spread to all parties (including designers and vendors) involved in the project. The requirements considerations should preferably be included in the bid specification for facility design and construction phases, but also for modification or decommissioning phases.

If the key steps towards SbD are taken, all stakeholders, including those not directly involved in the safeguards field (e.g., safety officers, security officers, engineering and maintenance teams, ...), can understand the role of nuclear non-proliferation and safeguards towards the safe and peaceful use of nuclear energy. They can also understand the necessity of considering safeguards in the project at its very early stage. As a result, the safeguards culture is strengthened and enhanced, and the licensee but also the other involved actors (e.g., designers and vendors) become understanding, more supportive and motivated to discuss safeguards requirements early. As already mentioned, this will help avoiding extra costs or delays caused by late equipment installations, additional inspection work or even mandated facility retrofitting modifications. The regulatory authority can then see the state's obligations and national objectives fulfilled efficiently and effectively, and the licensee benefits from timely and economical fulfilment of its obligations. The designers and vendors, on the other hand, can see a reduction in risks related to project schedule and budget. They also gain experience from an efficient implementation of IAEA safeguards, which can be valuable for future other nuclear related projects and can constitute a competitive advantage within the framework of their involvement in facility designs and changes.

In Finland, Fennovoima's nuclear power plant project organisation, currently working towards obtaining a construction licence, regularly negotiates with the plant supplier, RAOS Project Oy and Rosatom's design organisations, to integrate safeguards in the facility design. Fennovoima periodically reports to STUK on the progress in SbD work. In Posiva's spent fuel disposal project, on the other hand, SbD plays a central role in the facility design and construction process. The disposal facility consists of the encapsulation plant and the underground geological repository. The plant design has been revised twice after the licence application, thus the detailed plan for safeguards equipment has been modified after communication with the operator and according to the facility's needs. The SbD for the underground repository focuses on optimizing safeguards practices in different phases of the disposal process. In Belgium, for the SF<sup>2</sup> project, the purpose of which is to increase the capacity of the spent fuel elements storage at both NPPs of Doel and Tihange considering the former LTOs policies, early discussions have begun between the authorities and the operator ENGIE Electrabel. Before the launching of the pre-design phase of the project, FANC released a strategic note to the attention of the operator in which it explained its expectations in terms of safety, security and safeguards. Following this strategic note, the operator delivered during the pre-licensing phase of the project a Design Options and Provisions File (DOPF) in which it presented the selected nuclear safety, nuclear security and nuclear safeguards provisions derived from stated design and operational safety specifications as well as from technical and operational security requirements and safeguards obligations. During this phase, the discussions and comments on the safeguards parts were made in parallel to the work related to the Design Information Questionnaire (DIQ) / Basic Technical Characteristics (BTC) obligations. The DOPF, a complementary tool to the DIQ/BTC, has been a powerful asset that helped to initiate the safeguards related processes at a very early stage of the project from the operator side, but also it helped the operator to quickly communicate to the designers and vendors on safeguards related constraints and to spread the safeguards needs within the organisation. The spirit of the SbD approach followed for the SF<sup>2</sup> project was also strictly applied since the pre-licensing phase for the RECUMO project which is relating to the development of future processing capacities to allow recycling of HEU (and LEU) residues initially located at the IRE facility as LEU base material for further use. It should be emphasised that the RECUMO project is far more challenging than the SF<sup>2</sup> project due to the very nature of the future RECUMO processes. In this perspective also, the MYRRHA project case could be mentioned. MYRRHA stands for Multi-purpose hYbrid Research Reactor for High-tech Applications. This project would lead to the construction of a research reactor that could work also on ADS mode. Two of the goals of this project are to demonstrate the ADS concept and the feasibility of transmutation at pre-industrial scale. Also for this project, a strong SbD approach will be followed, while also taking into account lessons learned on safeguards implementation from previous projects in Belgium.

# Reflection points to explore for further improving the SbD concept implementation worldwide

As a consequence of the discussions and exchanges conducted during the virtual workshop organised jointly by STUK and FANC in April 2021, five Reflection Points for further improving the SbD concept implementation worldwide were identified. They are presented hereinafter.

## ***RP1 - SbD concept and provisions in the legal and regulatory framework:***

The Comprehensive Safeguards Agreement model (INFCIRC/153) stipulates that the design information of a new facility is to be provided to the IAEA as early as possible before nuclear material is introduced and not later than the time set in the Subsidiary Agreement which can be expressed in weeks to months prior to the start of the operation of the facility. The provision of this information in the form of the filled-in DIQ to the IAEA is the de facto starting point of the international safeguards implementation in many countries. A similar remark could be made for the earlier mentioned BTCs. It has been experienced that without separate national or regional legal requirements or intervention by, or guidance from the regulatory authorities, the operator finds it in most cases appropriate to provide the information in one consignment close to the deadline. This is reasonable from the operator's point of view when safeguards awareness is not strong enough, as it can appear to them to be the economical solution in the short term. We believe that the national (and regional) nuclear legislation and regulation could offer a solid but practical foundation for the SbD concept. Legal and regulatory provisions (including non-binding ones) on SbD are an icebreaker for early consideration of safeguards. In this regard, the Finnish nuclear legislation was updated for the first time in 2008 to take into account the experiences gathered especially from the Oikiluoto 3 project. The provision of preliminary design information relating to any new nuclear facility project within 60 days of the date of ratification of the parliamentary decision-in-principle is now a requirement in Finland, included into STUK's regulations in 2011. The updated legislation and regulation aim at introducing safeguards considerations as early as possible and at encouraging the operator to include safeguards in the bid specification to eventually have it included in the facility design. In Belgium, SbD considerations are stipulated in non-binding recommendation level documents delivered by the national authority responsible for safeguards matters.

## ***RP2 - SbD concept and provisions in the operators' policies and procedures:***

In its practical work, the operator is often represented by a manager and a team responsible for safeguards matters, often having a core function relating to the management of the nuclear material (e.g., FUEL team for a nuclear power plant). Their responsibilities and duties in the organisation may vary from the upper management to the operating and engineering levels. These functions and responsibilities may clearly not be ideal for involvement of safeguards matters in the design process of any project if no other function with a clear view on safeguards needs is involved. In addition, in the absence of a strong safeguards culture, it is observed that the management and decision-making roles at operating facilities often have a limited understanding of safeguards concepts, practices and needs. Unfortunately, for most of the organisations they are for these roles a foreign subject. This issue is also observed in the management involved in new facilities in project.

For efficient and effective safeguards, it is important to tear down the safeguards knowledge and responsibilities boundaries to spread it not only amongst the different actors of the operator directly involved in safeguards matters, but also at all the operator levels within the organisation in a balanced approach, including within the departments responsible for design and modifications matters. This remains, however, a challenge as long as there is no strong safeguards culture, in particular when safeguards are not properly understood and apprehended at the top management level.

For new nuclear facility projects, it is then highly crucial that safeguards culture and awareness already permeate the organisation at the pre-design phase. In a SbD spirit, timely awareness of safeguards in the organisation allows the operator to make safeguards an important part of its Integrated Management System before the facility exists. This will allow the operator to better identify and tackle safeguards challenges for any modification process to be conducted in the future (and even for the future decommissioning), as policies and procedures, including the ones not directly dealing with safeguards matters, will also take into account safeguards (including SbD) needs. It will also allow the operator to educate and train its staff on safeguards matters before final design decisions are made.

## ***RP3 - SbD concept and provisions to be taken into account in the change management policies and procedures:***

In line with the previously mentioned point and knowing that SbD approach should also be followed when modifications affecting material, systems, structures and components are to be conducted, it should be emphasised that the SbD concept and provisions should be included in the management system part dealing with the change and modification policies and procedures. In this regard, the operator could establish, following a graded approach, a system whereby modifications are categorised depending on their potential influence on the safeguards and then properly addressed for their safeguards part. For each change, this treatment could be initiated internally, and if required, then discussed and treated with the national and international authorities. Also, as a result, the interface with the other "2S" might be better managed thanks to this early and timely consideration of safeguards needs in an effective integrated "3S" vision. In this perspective, the associated beliefs, processes, practices, and responsibilities should be clearly outlined in the affected policies and procedures.

#### **RP4 - Reaching all stakeholders to be involved early in the (pre-)design and the (pre-)licensing phases:**

In the SbD mindset, the involvement of all stakeholders, including the designers and the vendors, as early as possible in the process is of fundamental importance to eventually reach efficient and effective safeguards.

With the support of the national and international regulatory authorities, the operator should be able to reach all stakeholders when proceeding to the licensing phase and when the bid specifications are worked, and especially when the needs in terms of services, material and equipment are identified. In particular, the designers and vendors should be able to understand and apprehend the non-proliferation and safeguards needs, and they should understand the added values and benefits they can offer in the set of projects in which they are involved, and the competitive advantage it represents especially in the nuclear industry. The national and international authorities could also implement, jointly with other organisations involved in the safeguards (e.g., Research & Development organisations) industry, outreach programs in a more proactive way in order to promote the safeguards and to spread the knowledge about the safeguards and SbD needs which have to be recognized as essential needs in the nuclear world. In this perspective, it is essential that the motivation for adopting the SbD approach is raised by presenting to all stakeholders, in a logical and clearly understandable manner, the benefits in terms of values, sustainable development, social responsibility and competitive advantages.

#### **RP5 - Phasing the safeguards concept and provisions to work on during the facility lifecycle (from the pre-licensing to the decommissioning):**

As already mentioned, the SbD approach should be followed for the entire lifecycle of any nuclear facility, from the pre-licensing stage up to the stage at which the declaration of the decommissioned status is released, also systematically when changes with potential influence on the safeguards within the existing facility are brought. In this perspective, three main phases can be defined: the commissioning phase, the operation phase and finally the decommissioning phase. We believe that there should exist a clear, well-defined and effective SbD phased approach and that many sub-phases could be identified for each phase (e.g., pre-licensing, licensing, construction,... permanent shutdown, closure,...) with defined associated safeguards tasks to be performed. Thus, each of these phases and sub-phases could be organised and conducted from a safeguards point of view following a structured step-by-step approach with validation and approval processes, also enabling the stakeholders to better understand the safeguards needs at each step even before they happen.

## **Ways forward**

At the current stage of our collaboration in the field of the SbD, the five above-mentioned reflection points to be explored for further improvement of the SbD concept implementation worldwide have been identified. STUK and FANC are willing to work together in the future to first address these points as a follow-up of the previously performed joint tasks in order to contribute to the enhancement and the improvement of the safeguards worldwide, knowing that SbD is essential for efficient and effective safeguards during the complete lifetime cycle of a facility. To conduct this work, STUK and FANC will regularly exchange information on their progress made, organise meetings, and will probably organise specific workshops targeting one or more of the aforementioned reflection points. In this perspective, STUK and FANC would like to call on each potential interested party, not only regional or state Authorities, but also research and development associations, designers, vendors and operators involved in the nuclear world, that would have been informed about our collaboration and its purpose, to contact us whether to be informed about the progress made and the status of our work, or to be informed about how to become part of this important joint venture. In addition, we would like to encourage each potential interested party, on their own or in collaboration with other parties, to address one or more of the reflection points identified and to report on it in order to spread knowledge within the safeguards and nuclear community. In this regard, STUK and FANC will openly report, at least once a year, on the progress they made in the framework of their collaboration.

## **Conclusion**

Through the SbD White Paper, and as consequence of their fruitful collaboration, STUK and FANC aim at sharing their experiences, points of view and reflections on the SbD implementation, hoping it will contribute to launching international cooperation initiatives towards the SbD approach in a continuous improvement vision. Indeed, we are willing to further increase international awareness of the SbD, to share our experiences and good practices, and to work together in an international framework, as we are convinced that SbD can contribute to developing and implementing safeguards, safely and securely.

The five Reflection Points presented in this paper focus on the need to provide to the stakeholders legal and regulatory provisions on SbD, including non-binding ones, and the need to address the safeguards concept and provisions in the operators' policies and procedures, to promote, to raise and to sustain within the organisations safeguards awareness, and to spread the safeguards knowledge, which is of particular importance when designing new facilities or bringing modifications to existing ones. Also, the focus is on the need to reach as early as possible all stakeholders, including the designers and vendors, to be involved in all phases during the whole facility lifecycle, from the pre-licensing to the decommissioning.

Finally, STUK and FANC emphasise that implementing SbD is a way of ensuring more effective and efficient safeguards implementation during the whole facility lifecycle, enabling also a better integration of safety, security and safeguards needs and obligations.