Institutionalizing Safeguards by Design: Opportunities and Challenges for Newcomer Countries

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ABSTRACT

With the expansion and evolving of Nuclear Power Plant technologies to more newcomer countries comes further burden on international safeguards. The need for intrinsic and extrinsic measure for the timely detection objective of safeguards. However, for newcomer countries, the burden is making up for the aspects of the international safeguards obligations of design not covered by the intrinsic design of the technology. When this is taken into account early in the design phase the nuclear power plant deployment, reduces the burden of time and cost on the operations, the SRA, and the IAEA. However, without the consideration of safeguards implication early in the design of the facility, safeguards solutions will need to be retrofitted into the design which will impact cost, time and possibly on security and safety. For newcomer countries, making it a requirement for the construction of nuclear facilities will enable the early considerations however, with this also come some challenges in its implementation some of which have been identified as communication, monetary implications as well as human resources. However, with these challenges there is also the opportunity of making provision for safeguards without adversely impacting on safety and security as this can be holistically considered. Using Ghana as a reference newcomer country, some proposals for possible solutions for the institutionalisation of safeguards by design by newcomer countries to promote the implementation of international safeguards for the deterrence and/or detection of proliferation of nuclear weapons.

INTRODUCTION

With the expansion and evolution of nuclear energy technologies comes the increased burden on the implementation of international nuclear safeguards. There is the need for safeguards technologies, measures, and implementation to also evolve as well at the least along with the nuclear energy technologies. This requires the strategies that will allow for an improved effective and efficient safeguards implementation. The current international safeguards regime is set to provide verification for the existing nuclear facilities and thus for the new development in nuclear power technologies, there is the need for the adaptation of international nuclear safeguards mechanisms to support the evolving nuclear fuel cycle.

Safeguards by design (SBD) concept is one such strategy. This seeks to integrate international safeguards regime early in the design phase of a new nuclear facility and suggests early discussions on design and constructive dialogue between the stakeholders. The SBD process is a multidisciplinary interactive process of optimizing the design features and process parameters of the facility to ensure that safeguards obligations can be reasonably met. The overarching goal of the promotion of SBD is to make sure that international nuclear safeguards requirement is fully integrated into the design process of a nuclear facility to allow the effective and efficient implementation of international nuclear safeguards which will in turn support the growth of nuclear power but at the same time ensuring that nuclear materials are used for peaceful purposes only. (IAEA, 2013; T. Bjornard et. al., 2009, IAEA, 2001)

IAEA safeguards is integrally linked to nuclear material ensuring they are fully accounted for and also have the following as its main goals. (Durst et. al., 2012)

- Detect the diversion of 75 kg of U-235 in the form of natural, low-enriched (LEU) or depleted uranium fuel within one year.
- Detect the diversion of 8 kg of plutonium in the form of core or spent fuel within 3 months.
- Detect the diversion of 8 kg of U-233 in the form of core or spent fuel within 3 months.
- Detect the diversion of 20 tonnes of thorium in the form of fuel within one year.
- Detect the undeclared production of 8 kg of plutonium or U-233 within one year.

Thus, the IAEA implements safeguards and verifies to ensure that countries comply with their nuclear safeguards agreement. For the implementation of safeguards there are several requirements placed on countries which include but not limited to the provision of nuclear facility design and operating information, provide IAEA the opportunity to verify safeguards relevant information, activities, and features. It is in this vein that safeguards by design (SBD) concept presents the opportunity to introduce safeguards engagement early in the design of a nuclear facility.

With the potential of minimizing proliferation and security risk, it is prudent to promote the institutionalisation of safeguards by design (ISBD) especially for newcomer countries. ISBD simply refers to the implementation of a structured approach by which international and national safeguards, physical security, and other non-proliferation objectives are fully integrated into the overall design and construction process of a nuclear facility from the initial planning through design, construction, and operation. (T. Bjornard et. al., 2009) The question then is how can this SBD be institutionalised especially by newcomer countries? What opportunities are there and what possible challenges may arise to in support of achieving the detection goals of international nuclear safeguards. This paper discusses the opportunities newcomer countries have to institutionalise safeguards-by-design in support of the implementation of international nuclear safeguards.

SAFEGUARDS BY DESIGN PROCESS

Safeguards by design is a structured approach that systematically integrates international and national safeguards, physical protection, and other barriers into the design and construction process of a nuclear facility. The SBD process requires the understanding of proliferation resistance and the underlying principles by the designers, operator in collaboration with safeguards subject mater experts with the aim of improving the procedures of interaction of systems of accounting and control.

For the establishment of a new nuclear facility, there are some major stages involved. These are the pre conceptual design stage, conceptual design stage, Preliminary design stage, the Final design stage, the construction, and the operation stage. At each of these stages there is the activity for the implementation of safeguards. The incorporation of safeguards early in the design phase of the facility will help with the optimal combination of safety security and safeguards requirements.

Typically, the key features of the safeguards by design are as follows.

- The involvement of safeguards subject matter experts in the early phase of the design of the facility.
- The identification of safeguards requirement and intrinsic features relevant to safeguards that will be beneficial to the design.
- The integration of safeguards with project design.
- Development of interaction plan between safeguards and the design process that identifies required activities and their timeline while providing details and analysis at each phase of the design cycle.
- Requirements for owner/ stakeholder approval for safeguards design approaches and associated risks at key decision points.
- Flexibility to incorporate all regulatory requirements into the design of nuclear facilities.

OPPORTUNITIES AND BENEFITS OF INSTITUTIONALISING SBD

Institutionalising SBD is key to the improvement of the implementation of safeguards in the fast-evolving technology. As this holds major benefits to global implementation of international safeguards., institutionalising SBD is dependent on three key pillars. These pillars are requirements definition, design processes and technology and methodology.

Requirements for both national and international safeguards are all important for the success of the implementation of SBD. Considering the pillars of ISBD and the 3-phase approach for nuclear power programme development, newcomer countries do have opportunities to achieve full benefits of the implementation of SBD. Figure 1 presents the schematic representation of the phases and milestones. (IAEA, 2015)

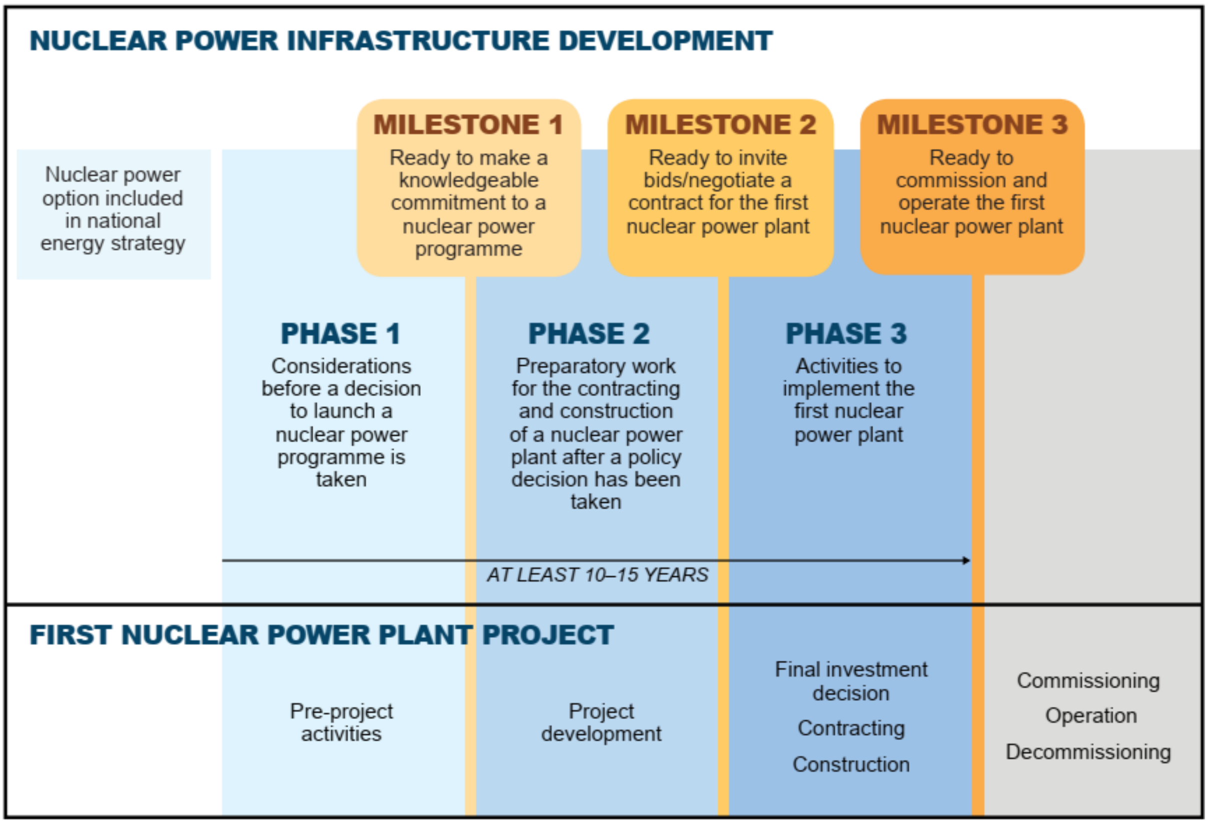

Figure 1: Schematic Representation of the Phases and milestones.

With the main objective of development of a formalised process in the integration of non-proliferation, safeguards and security into the design, construction and the operation of a nuclear facility, table 1 presents a summary of relevant nuclear programme development infrastructural issues that are relevant to nuclear safeguards and some of the opportunities they present to newcomer countries. These infrastructural issues are addressed in all three phases of a nuclear programme.

Capitalising on the duration of the different phases of the milestone approach for the development of a nuclear power programme as well as the multidisciplinary and coordinated nature of a nuclear programme, during the first phase which is a pre-conceptual stage, the establishment of a team with safeguards subject matter experts along with the relevant infrastructural issues to design and implement an SBD process where all the assessments carried out in the various relevant issues will be collated to support the integration of safeguards into the design of the facility during the phase one of the programme for to give a good foundation to the building – on as the programme progresses. The creation of this team as early as the first phase of the programme is key fundamental step of SBD process. At this stage, the team thus supports in ensuring the integration of safeguards, security, and non-proliferation into the design process.

Table 1: Summary of relevant infrastructural issues and opportunities

<table>
<tr><th>Infrastructure Issues</th><th>Summary description</th><th>Opportunities</th></tr>
<tr><td>Legal framework</td><td>National legislation comprehensively covering all aspects of nuclear law.</td><td rowspan="10">1.Building Capacity

2. Assessment of the overall implication of the programme for safeguards.

3. Ensuring State Safeguards Authority and related organisations are well resourced (especially with necessary authority) to ensure all international obligations can be met effectively and efficiently.

4. Define and Design structure and systems for implementation of safeguards and allied obligations.

5. Incorporation of necessary requirements into regulatory documents.

6. Effective and efficient synergy (integration) of safety, security, and safeguards by design. Reducing the possibility of misalignment of the 3 S

7. Broader engagement with all stakeholders.</td></tr>
<tr><td>Funding and Financing</td><td>Funding requirement and financing options.</td></tr>
<tr><td>Safeguards</td><td>Clear commitment to international non-proliferation obligations</td></tr>
<tr><td>Regulatory Framework</td><td>Establishment of a competent, independent well-resourced regulatory body</td></tr>
<tr><td>Human Resource Development</td><td>Knowledge and skills necessary to introduce</td></tr>
<tr><td>Stakeholder Involvement</td><td>Plans and strategies on stakeholder engagement to facilitate stakeholder support</td></tr>
<tr><td>Nuclear Security</td><td>Prevention of, detection of and response to intentional unauthorized acts related to nuclear materials and other radioactive materials and associated facilities and activities</td></tr>
<tr><td>Nuclear Fuel Cycle</td><td>Fuel Cycle Strategy - Fuel cycle has two components</td></tr>
<tr><td>Industrial Involvement</td><td>Commodities, components, and services sourcing</td></tr>
<tr><td>Procurement</td><td>Purchasing equipment and services</td></tr>
</table>

In this way, stakeholder interaction is broadened and well defined as this will include both national and international stakeholders since most newcomer countries are required to comply with both national and international requirements and obligations. Table 2 shows stakeholder interactions and information exchange with respect to the SBD concept. The early continuous consideration of national and international safeguards interactions between all the key stakeholders will allow an effective safeguard into the design. It will also provide the opportunity for all interested parties to work together to build international confidence and reduce the potential of unforeseen impacts on nuclear facility operators during the construction and operation of the facility. (IAEA, 2014)

As safeguards by design incorporates physical security, material control and accounting, international safeguards and proliferation barrier, another opportunity during the first phase of the programme as indicated in table 1 is the overall assessment of safeguards implications based on technology. Proliferation resistance and physical protection assessment of the various intended technologies. This will allow for consideration on the specific technology characteristic in relation to relevant state specific attributes. Also, both front end and back end of the technology's fuel cycle will thus be considered holistically to inform decision on the implication of choice technology on safeguards and the states' responsibility in that regard.

Benefiting from early engagement with IAEA and designer, newcomer countries have the opportunity to states have the opportunity to ensure all safeguards and related requirements are factored in the design and provisions made into the bidding process thus the likelihood of possible delays and cost related to provisions for safeguards implementation is greatly reduced.

The discussed opportunities with other possible opportunities being considered, institutionalising SBD by newcomer countries give the state to enjoy the full benefits of (Peel, 2022, IAEA, 2013)

- Reducing the risk of project delays
- Reducing the risk of costly retrofitting
- Enhancing the possibility to use advanced technologies like unattended monitoring systems.
- Facilitating the joint use of equipment and
- Reducing burden on operators and the IAEA by optimising inspections.

Table 2 Safeguards interactions in SBD (IAEA, 2013)

<table>
<tr><th>Stakeholder</th><th>Pre conceptual design</th><th>Preliminary Design</th><th>Final Design</th><th>Construction</th><th>Operation</th></tr>
<tr><td rowspan="3">Safeguards Authority</td><td>Review of potential safeguards measures and allied obligations</td><td>Approval</td><td rowspan="3">Draft facility attachment</td><td rowspan="3"></td><td rowspan="3">Final facility attachment</td></tr>
<tr><td>Approval</td><td>Design information questionnaire</td></tr>
<tr><td>Preliminary design information to IAEA</td><td>Feedback to operator</td></tr>
<tr><td rowspan="4">IAEA</td><td>Provision of a list of possible safeguards measures for the facility type.</td><td>Medium level safeguards guidelines.</td><td rowspan="4">Detailed safeguards guidelines. Design information evaluation.
Feedback to the relevant
safeguards authority.</td><td rowspan="4">Detailed SG guidelines.
Design Information evaluation.</td><td rowspan="4">Feedback to the relevant
safeguards authority</td></tr>
<tr><td>List of potential safeguards measures.</td><td>Possible safeguards approaches</td></tr>
<tr><td rowspan="2">State level safeguards requirements; high level safeguards guidelines.</td><td>Detailed safeguards guidelines. Design information evaluation.</td></tr>
<tr><td>Feedback to the relevant safeguards authority.</td></tr>
<tr><td rowspan="4">Operator</td><td>Preparation of pertinent information.</td><td>Preliminary design information approval.</td><td rowspan="4"></td><td>Safeguards equipment installation.</td><td>Safeguards testing. Possible feedback to equipment supplier.</td></tr>
<tr><td>Call for tenders to designers/suppliers.</td><td>Feedback to designer.</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>Tender selection.</td><td rowspan="2"></td></tr>
<tr><td>Approval</td></tr>
<tr><td rowspan="2">Designer</td><td>Facility pre-concept tenders.</td><td>Preliminary design.</td><td rowspan="2"></td><td rowspan="2"></td><td>Possible feedback to equipment supplier</td></tr>
<tr><td>Preliminary design concept.</td><td>Feedback to safeguards equipment supplier.</td><td></td></tr>
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POSSIBLE CHALLENGES OF INSTITUTIONALISING SBD

Since the burden of safeguards primarily falls on the IAEA and states, vendors and designers lack the motivation to facilitate safeguards considerations in their design elements. For this reason, the key responsibility of assessment of facility safeguardability assessment, proliferation resistance and physical protection assessment lies on the newcomer country, and this presents the challenge of communication, human resources as well as financial implication.

For assessment during the early phase (pre-feasibility) to receiving specific data which is not publicly available for the various technologies may prove to be a challenge making it difficult for a comprehensive safeguardability assessments as well as proliferation resistance and physical protection assessments. (Pomeroy et at., 2008, Coles et at., 2013, Bari et. Al. 2009)

Also, for newcomer countries with limited nuclear activities, availability of human resources in this area will be limited. Also, most newcomer states nuclear technical educations mostly cover safety and security issues, and these are directly the responsibility of the state. However, because safeguards is the responsibility of IAEA it is not featured in curriculums of nuclear technical education and training programmes. This can affect the comprehensive and effective implementation of SBD. Though a challenge can also be an opportunity as nuclear programmes develop, and states improve their national nuclear capacity with appropriate stakeholder engagement.

CONCLUSION

This paper set out to discuss the possible opportunities and challenges for the institutionalisation of safeguards by design concept. It is envisaged that the widespread institutionalization and implementation of SBD will be beneficial to the effective implementation of international safeguards.

Also the early interaction of all the stakeholders in the SBD process will help in early implementation of SBD therefore reducing the cost elements in the project as well as reducing nuclear security and safety risk in the future.

Lastly, the early implementation of the safeguards by design will increase the effectiveness and efficiency of the safeguards design process as part of nuclear facility design, construction, and operation.

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