

# Proliferation Resistance and International Safeguards

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## **Abstract**

*Proliferation resistance are those characteristics of a nuclear energy system that impede the diversion or the undeclared production of nuclear material, or the misuse of technology, by States intent on acquiring nuclear weapons or other nuclear explosive devices. The degree of proliferation resistance results, inter alia, from a combination of technical design features, operational modalities, institutional arrangements and safeguards measures. The institutional arrangements and technical design features of a nuclear energy system, as well as the operational modalities, may have the ability to both facilitate the implementation of international safeguards and reduce the safeguards effort. Institutional arrangements may have an impact on safeguards mainly at the State level, whereas technical design features may have an impact on safeguards at the facility level. Regardless of the degree of proliferation resistance international safeguards will remain essential. Moreover, design features introduced at early design stages and aimed at facilitating the implementation of international safeguards will improve the proliferation resistance of nuclear energy systems.*

## **1. Introduction**

Looking ahead, the use of nuclear energy is likely to expand. The growing interest of States in nuclear power is driven, *inter alia*, by the need to meet increasing energy demands, enhance security of supply through diversification of energy resources, and reduce carbon emissions which are linked to climate change. However, the expansion of nuclear energy may also increase proliferation risks.

To minimize the proliferation risks associated with a possible nuclear renaissance the international community has conducted substantial work on the proliferation resistance of future nuclear energy fuel cycles and related facilities over the last few years [1,2]. Intrinsic proliferation resistance features, combined with extrinsic proliferation resistance measures, may help to ensure that future nuclear energy systems will continue to be unattractive means for acquiring nuclear material for a nuclear weapons programme. In this context, it is commonly understood that the implementation of international safeguards will remain essential for the proliferation resistance of a nuclear energy system. Incorporating features into the design phase for new facilities to facilitate the implementation of safeguards will allow the International Atomic Energy Agency (IAEA) to more effectively and efficiently monitor and verify nuclear material [3].

## **2. Safeguards**

All non-nuclear-weapon States party to the Treaty on Non-Proliferation of Nuclear Weapons (NPT), as well as States party to regional nuclear-weapon-free zone treaties, are required to conclude a comprehensive safeguards agreement (CSA) with the IAEA. The structure and content of a CSA concluded pursuant to the NPT are described in document INFCIRC/153 (Corr) [4]. For a State with a CSA, an additional protocol that includes all provisions of the Model Additional Protocol, as documented in INFCIRC/540 (Corr.) [5], is designed to strengthen the effectiveness and improve the efficiency of the IAEA safeguards system as a contribution to global non-proliferation objectives.

The technical objective of IAEA safeguards is “the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other

nuclear explosive devices or for purpose unknown, and deterrence of such diversion by the risk of early detection” [4]. Roughly summarized, international safeguards comprise four main elements: nuclear material accountancy, containment and surveillance, in-field verification, and information evaluation. Accountancy measures require a State to report to the IAEA the types and quantities of nuclear material under its control, through an established State System of Accounting for and Control of Nuclear Material (SSAC). Containment and surveillance measures are applied by the IAEA through, e.g., the use of seals on nuclear material containers and monitoring (film, TV) of key areas at nuclear facilities. Inspections are carried out by IAEA inspectors to verify the declared location and quantity of nuclear material and the absence of any undeclared material and activities. Evaluation of information uses all available sources of information about a State’s nuclear programme.

For States with comprehensive safeguards agreements and additional protocols in force, the IAEA aims to provide through its safeguards system assurance regarding not only the non-diversion of nuclear material from peaceful use but also the absence of undeclared nuclear material and activities.

As stated in the Expert Group Report on Multilateral Approaches to the Nuclear Fuel Cycle: “Safeguards, rationally and well applied, has been the most efficient way to detect and deter further proliferation and to provide State parties with an opportunity to assure others that they are in conformity with their safeguards commitments”. And, “In fact, the primary technical barriers against proliferation remain the effective and universal implementation of IAEA safeguards under comprehensive safeguards agreements and additional protocols, and effective export controls”. [6]

### 3. Proliferation Resistance

In the design of future nuclear energy systems, it is important to consider the potential for such systems to be misused for the purpose of producing nuclear weapons. This is a key issue of the international non-proliferation regime, with its many national and multinational agreements and institutions; the IAEA safeguards system is a fundamental element of this regime. While almost any nuclear energy system can be adequately safeguarded with sufficient effort and resources, the cost of providing safeguards assurances depends on the nature of the nuclear fuel cycle of a State. Should nuclear power based on existing technologies greatly expand, the detection of the diversion of nuclear material, or misuse of facilities dedicated to the peaceful use of nuclear energy, or of undeclared nuclear materials or activities, will become increasingly costly.

Therefore in the design of future nuclear energy systems it is essential that their proliferation resistance be increased. In this context, *Proliferation Resistance* refers to the characteristics of a nuclear energy system that impede the diversion or the undeclared production of nuclear material, or misuse of technology, by States intent on acquiring nuclear weapons or nuclear explosive devices [7].

The degree of proliferation resistance results, *inter alia*, from a combination of technical design features, operational modalities, and institutional arrangements and safeguards measures. These can be classified as *intrinsic features* and *extrinsic measures*. Intrinsic features result from the technical design of a nuclear energy system, including those features that facilitate the implementation of safeguards. Extrinsic measures are based on a State’s decisions and undertakings related to its nuclear energy system.

Intrinsic features consist of technical features that:

- a) Reduce the attractiveness of nuclear material for nuclear weapons programmes during production, use, transport, storage and disposal, including material characteristics such as isotopic content, chemical form, bulk and mass, and radiation properties;
- b) Prevent or inhibit the diversion of nuclear material, including the confinement of nuclear material to locations with limited points of access, and materials that are difficult to move without being detected because of size, weight, or radiation;
- c) Prevent or inhibit the undeclared production of direct-use material, including reactors designed to prevent undeclared target materials from being irradiated in or near the core of a reactor; reactor cores with small reactivity margins that would prevent the operation of the reactor with undeclared targets; and fuel cycle facilities and processes that are difficult to modify; and
- d) Facilitate nuclear material accountancy and verification, including continuity of knowledge.

Five categories of extrinsic measures are defined as follows:

- a) Commitments, obligations and policies of States, such as the NPT and IAEA safeguards agreements and protocols additional to such agreements;
- b) Agreements between exporting and importing States on the exclusive use of nuclear energy systems for agreed purposes;
- c) Commercial, legal or institutional arrangements that control access to nuclear material and technology;
- d) Verification measures by the IAEA, or regional, bilateral or national measures; and
- e) Legal and institutional measures to address violations of the measures defined above.

Extrinsic proliferation resistance measures, such as control and verification measures, will remain essential, whatever the level of effectiveness of intrinsic features.

#### **4. State-Specific Safeguards Considerations and Proliferation Resistance**

The basis for the implementation of international safeguards for a State is the State evaluation process, a continuous, iterative process conducted by the IAEA for each State with a safeguards agreement. The process integrates and assesses all of the information available to the IAEA about the State's nuclear activities and plans. The information is mainly that provided by the States pursuant to safeguards agreements and additional protocols or voluntarily; information obtained by the IAEA through its in-field verification activities; and safeguards-relevant information obtained by the IAEA from open sources and other external sources.

For a State State-specific objectives are established that determine the relative level and focus of the safeguards activities needed for the IAEA to draw soundly-based safeguards conclusions. The State-specific objectives take into account: the features and characteristics of the State's nuclear activities and capabilities, as identified in the State evaluation; the IAEA's experience in implementing safeguards in the State; and the State-specific conditions for the implementation of safeguards measures.

State-specific factors, technical and non-technical, to be taken into account in establishing safeguards measures are, *inter alia*:

- The scientific, technological and industrial infrastructure of the State, the status of nuclear capabilities, nuclear research, the total amount of nuclear material and future planning as declared by the State, which can be used for estimating the time and effort required for a State to implement a nuclear weapon programme;
- The international interdependence of fuel cycle facilities (e.g. multinational ownership, management and operation);
- The dependence of the State's nuclear activities on other States (e.g. no indigenous supply of uranium or thorium, no indigenous fuel fabrication capabilities); and
- The State's acceptance of and demonstrated commitment to non-proliferation norms.

State-level proliferation resistance attributes that have or may have an impact on the safeguards effort at the State-level are primarily:

- A CSA and an additional protocol in force, enabling the IAEA to integrate safeguards activities in an optimal way and thereby achieve greater overall effectiveness and efficiency;
- Multinational ownership and management and control of nuclear energy systems that may allow for reduction in the safeguards activities in the State. The rationale for such reductions would be that a diversion of nuclear material or the misuse of a facility may be less likely when nuclear authorities from two or more States need to conspire in order to execute and conceal the diversion or misuse; and
- Multilateral approaches to the nuclear fuel cycle (e.g. international centres for front-end and back-end fuel cycle facilities, Global Nuclear Energy Partnership (GNEP)).

The design of a State-level safeguards approach that takes into account State-specific safeguards considerations is shown in Fig.1

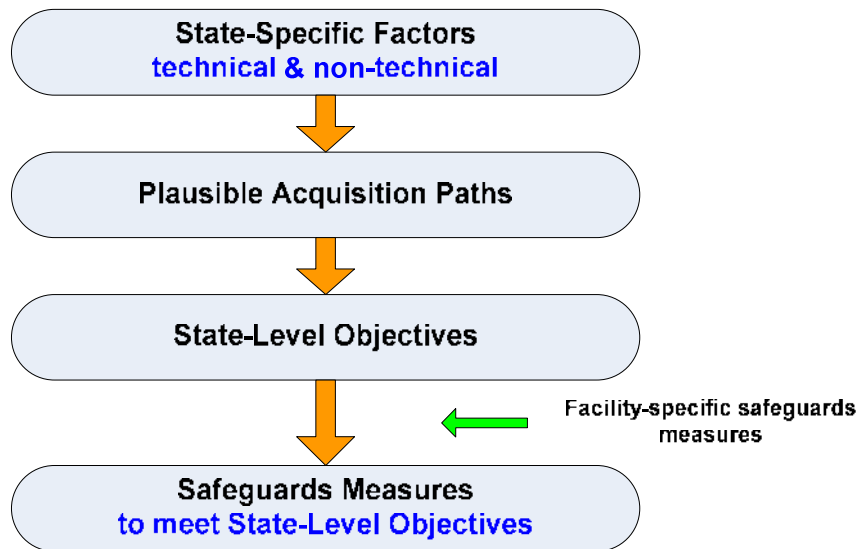


Fig. 1: State-specific Safeguards Considerations for Design of a State-level Safeguards Approach

## 5. Facility-Specific Safeguards Considerations and Proliferation Resistance

Safeguards measures at the facility level are determined by safeguards relevant characteristics of the facilities. Relevant characteristics are:

- Material type (plutonium, high enriched uranium, U-233, depleted, natural and low enriched uranium; and thorium) [8];
- Material category according to the irradiation status and suitability for conversion into components of nuclear explosive devices (unirradiated direct use material, irradiated direct use material and indirect use material [8]);
- Facility type; and
- Facility inventory and throughput.

The inspection goal for a facility generally consists of a quantity component and a timeliness component. The safeguards effort required to meet the inspection goal at the facility level depends, *inter alia*, on the sensitivity of the nuclear material and nuclear technology and the capabilities for misuse in order to acquire weapon usable material; and on the State's legal commitments.

The design of a facility-level safeguards approach that takes into account facility-specific safeguards considerations is shown in Fig. 2. However, for such an approach to be both effective and efficient the support of designers and operators is needed to implement those design features and operational modalities that facilitate safeguards implementation.

Facility-level proliferation resistance attributes that have or may have an impact on the safeguards effort at the facility-level are:

- Material category (unirradiated direct use material, irradiated direct use material and indirect use material);
- Material quality (suitability for a nuclear explosive device, e.g. low percentage of fissile plutonium);
- Attractiveness of nuclear technology (proliferation sensitivity);
- Complexity of nuclear technology (potential diversion and misuse scenarios);
- Accessibility of facilities and nuclear material for IAEA inspectors;
- Accountability (uncertainty of the material balance, safeguards measurement capability);

- Availability of accounting and safeguards relevant operating data;
- Amenability of monitors providing information on the flow of nuclear material or on the status of a facility or equipment; and
- Possibility of remote data acquisition.

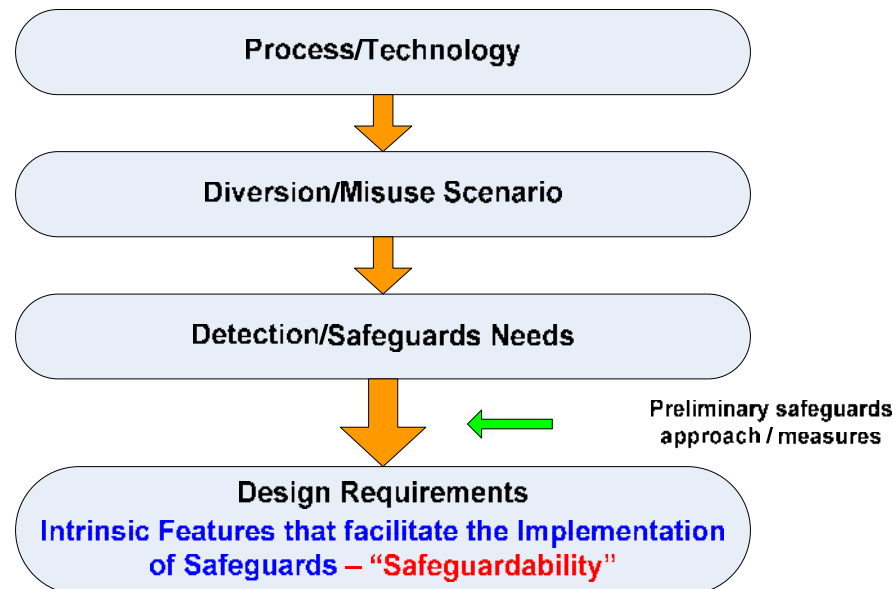


Fig. 2: Facility-specific Safeguards Considerations for Design of a Facility-specific Safeguards Approach

## 6. Conclusions

Effective and efficient implementation of international safeguards will remain essential for the proliferation resistance of a nuclear energy system, regardless of the level of effectiveness of proliferation resistance intrinsic features.

Design features introduced at early design stages and aimed at facilitating the implementation of international safeguards will improve the proliferation resistance of nuclear energy systems.

## References

- [1] IAEA-TECDOC-CD-1575, Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems, INPRO Manual – Proliferation Resistance, Volume 5 of 9 of the Final Report of Phase 1 of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), October 2007.
- [2] GIF/PRPPWG/2006/005, Evaluation Methodology for Proliferation Resistance and Physical Protection of Generation IV Nuclear Energy Systems, Revision 5, November 30, 2006.
- [3] U.S. Department of Energy, Global Nuclear Energy Partnership, Implementing Elements, Nuclear Safeguards ([www.gnep.gov/gnepProgram.html](http://www.gnep.gov/gnepProgram.html)).
- [4] INTERNATIONAL ATOMIC ENERGY AGENCY, The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on Non-Proliferation of Nuclear Weapons, INFCIRC/153 (Corrected), IAEA, Vienna (1972).
- [5] INTERNATIONAL ATOMIC ENERGY AGENCY, Model Protocol Additional to the Agreement(s) between State(s) and the IAEA for the Application of Safeguards, INFCIRC/540 (Corrected), IAEA, Vienna (1997).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Multilateral Approaches to the Nuclear Fuel Cycle, Expert Group Report to the Director General of the IAEA, INFCIRC/640, IAEA, Vienna (2005).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, DEPARTMENT OF SAFEGUARDS; Proliferation Resistance Fundamentals for Future Energy Systems, STR-332, IAEA, Vienna (2002).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safeguards Glossary 2001 Edition, International Nuclear Verification Series No. 3, Vienna (2001).