Chapter 19

Adapting Non-proliferation Approaches to a Changing World: A European Expert's Viewpoint

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Introduction—The first reflections over the development of nuclear energy and the need for a non-proliferation regime were engaged in the aftermath of WW2 and publicized in 1953 by President Eisenhower in his historical speech, “Atom for Peace”.

The peaceful uses of nuclear energy developed very significantly since then, demonstrating the success of the non-proliferation policies and mechanisms, contradicting President Kennedy’s fears expressed in 1963 that as many as 15–25 Nations would be possessing nuclear weapons in the 1970s. We are some 50 years and this number is “limited” to 9 States.

In terms of non-proliferation, the regime instituted in the late 50s/60s has also evolved in response to specific challenges or crises, in particular with the peaceful atomic explosions in India or the findings in Irak where the IAEA was not empowered to detect non declared activities. Other situations (Iran- DPRK) have not been met with an evolution of the institutional framework but rather have demonstrated some flaws or weaknesses of the system.

In 2004, Libyan clandestine activities were put to an end thanks to the negotiations launched by the US and the UK. Finally, another major violation of non-proliferation commitments was discovered with the clandestine construction of a reactor in Syria. This situation was met by the unilateral Israeli military action that destroyed the plant.

In terms of nuclear energy, the period is characterized by an expansion both in its contribution to the energy balance and geographically. Today as many as 30 countries have at least one NPP (1) with major developments in Northern America but also in Europe, Russia and Asia, mainly Japan and China.

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However, the Chernobyl accident in 1986 seriously impacted the development of nuclear energy namely in the EU and the prospects for an anticipated “nuclear renaissance” was just killed.

The perspectives for nuclear energy development in the next 30 years are uncertain but the global nuclear landscape will be very different.

The nuclear non-proliferation regime covers both horizontal and vertical proliferation and thus includes efforts towards the elimination of nuclear weapons. However, although there are connections between both aspects, this paper focuses on the horizontal proliferation, that is on efforts to deter, or possibly detect and react to proliferation attempts from States not possessing nuclear weapons.

The non-proliferation regime today is a complex but rather comprehensive global framework with some weaknesses—The nuclear non-proliferation regime is heavily dependent on the Nuclear Non Proliferation Treaty (NPT) that was open to signature in 1968. It is the most universal International Treaty while being subject to recurring criticisms as being unfair given the different status and obligations of NNWS and NWS. It is flawed with the legal and practically the political impossibility to offer any derogatory status to allow the adherence of new States or “de facto” States, possessing nuclear weapons. It also lacks any efficient provisions to deal with the case of non-compliance or breakout. Its limits were demonstrated when DPRK chose to step out of its commitments under the Treaty using a “national security” clause without allowing a proper international response.

However, the NPT has gained almost universal adherence, has been indefinitely prorogated in 1995, and is complemented with a series of agreements that can be seen as implementing tools.

The NPT calls for States to put nuclear material under the safeguards of the IAEA.

Although the obligations are different between a comprehensive safeguards agreement, a Verification Offer Agreement and a facility type agreement, all States with significant nuclear activities do have a safeguards agreement in place. This includes the 5 Nuclear Weapon States but also India and Pakistan although not Parties to the NPT.

Nuclear non-proliferation assurances are delivered by the IAEA thanks to the safeguards strategy and verification work implemented by its Department of Safeguards.

“The objective of IAEA safeguards is to deter the spread of nuclear weapons by the early detection of the misuse of nuclear material and technology. The IAEA verifies that nuclear facilities are not mis-used and nuclear material is not diverted from peaceful uses”.

The safeguards’ approaches and the concepts applied have been refined over the years.

Today the State level Approach based on the analysis of an acquisition Path assessment is implemented in 54 States whereby all plausible way for a State to obtain nuclear material usable in a nuclear weapon or in a nuclear device are analyzed and technical objectives are to be met to detect any diversion.

Most but not all safeguards agreements are now complemented with an Additional Protocol that allows the IAEA to get extended access and information to be able

to detect not only the diversion of declared material but also possible clandestine activities.

The task of the safeguards Department has been growing with those new agreements but also with specific efforts that have to be devoted when a situation arises (in particular nowadays with the Iran case) where new inventories are to be taken and new safeguards schemes are to be designed and implemented. This calls for additional financial and human resources. Out of the 2019 IAEA budget of 375.2 Million 145 M€ are allocated to the Department of Safeguards, which represents about 39% of the total budget, with a staff of 918 persons in 2018.

Other safeguards activities are carried out at a regional level, in the EU under the Euratom Treaty and between Brazil and Argentina through a common body, ABBAC.

These safeguards and controls in turn can partly support IAEA's activities in the countries covered by such arrangements.

The safeguards system is itself complemented with the Nuclear Suppliers' Group export control guidelines. These Guidelines only reflect political commitments of its Members and are not legally binding. However, it is a very useful tool to disseminate good practices, review and agree on the nuclear and dual use items and technology which export should be subject to specific conditions, restraint or even refusal (denials). Most of supplier States and States of transit are Members of the NSG. NSG suppliers require to have a bilateral agreement in force to allow the export of sensitive nuclear goods and services. Thanks to the NSG, the main conditions that are requested to importing States and contained in bilateral nuclear arrangements are more and more standardized (full scope safeguards agreement, export control, or no export without agreement, adoption of international safety and security Conventions and implementation of IAEA's recommendations).

Such cooperation agreements can also be required at a regional level as it is the case with Euratom.

The intersection between security and non-proliferation—Nuclear non-proliferation policies as described above generally address attempts by a State to acquire a nuclear weapon or device. However, individuals or groups of individuals may try to acquire, nuclear material, technology or even weapons for terrorist purposes or in exchange of money or other goods or favors from proliferating States.

In that respect, nuclear security measures may be considered as part of nuclear non-proliferation policies.

Measures to deter, detect, and possibly recover material obtained through theft do complement the institutional, legal, or political measures described above.

Responsibility over security issues are left to each State, with the IAEA developing guidelines, technical support and a forum for exchanging on good practices. At the international level however, the CPPNM was adopted in 1980 and entered into force in 1987 in particular to ensure international transport of nuclear material would be covered by agreed security measures/levels. An amendment to the Convention entered into force about 30 years later, in 2006. This amendment extends the scope of the CPPNM to material, facilities and storage at domestic locations and in case of sabotage. It also extends the scope for international cooperation to recover material or mitigate the radiological effects of acts of sabotage or terrorism.

Fig. 19.1 Population size by region, 2019, 2050 and 2100 (billions)

Both Convention and Amendment are legally binding instruments.

Another Convention to be mentioned here is the International Convention for the Suppression of acts of nuclear terrorism that was adopted in 2007. This convention aims at promoting international cooperation to prevent acts of terrorism and punish the perpetrators.

A changing nuclear landscape—When Looking ahead with a 20/30 years horizon and trying to assess what may be the major challenges to the regime apart of political risks of breakouts, it is necessary to have a fair vision of the nuclear landscape; where nuclear will be developing and what types of technologies will be available.

Changing Nuclear distribution—The world population is predicted to go up to 2 billion in 2050, with 9.7 billion persons, with the largest increase in sub-Saharan Africa (double by 2050).¹

The distribution of the world population will be changed as illustrated on the following graph (Fig. 19.1).

This increase in population will go together with the growth of energy demand and a larger share of electricity demand. In that context, IAEA² predicts in both its high and low scenarios, a net increase in nuclear energy output, (more than double the 2018 output in the high scenario and about +16% in the low scenario), although this will not

¹“Report of the UN issued on 17/06/2019 “Nine countries will make up more than half the projected population growth between now and 2050 The largest increases in population between 2019 and 2050 will take place in: India, Nigeria, Pakistan, the Democratic Republic of the Congo, Ethiopia, the United Republic of Tanzania, Indonesia, Egypt and the United States of America”.

²The 39th edition of the IAEA report Energy, Electricity and Nuclear Power Estimates for the Period up to 2050.

Table 19.1 World total and nuclear electrical generating capacity

Electrical capacity	2018	2030 ^a		2040 ^a		2050 ^a	
		Low	High	Low	High	Low	High
Total [GW(e)]	7188	9782		11,811		13,633	
Nuclear [GW(e)]	396	366	496	353	628	371	715
% of total	5.5	3.7	5.1	3.0	5.3	2.7	5.2

^aNuclear capacity estimates take into account the scheduled retirement of older units at the end of their lifetime

Table 19.2 World total and nuclear electrical production^a

Electrical production	2018	2030		2040		2050	
		Low	High	Low	High	Low	High
Total (TW h)	25,196	33,538		41,101		49,032	
Nuclear (TW h)	2563	2836	3844	2804	4977	2990	5761
% of total	10.2	8.5	11.5	6.8	12.1	6.1	11.7

^aThe nuclear production data presented in this table and the nuclear electrical generating capacity data presented in Table 19.1 cannot be used to calculate average annual capacity factors for nuclear plants as Table 19.1 presents year-end capacity

be matched equally by an increase in the capacity: there should be a slight decrease of the capacity in the low scenario (6%) but a large increase in the high scenario (80%). This is explained by performance gains. Given the expected retirement of older plants, this trend will undoubtedly equate with a significant number of new builds.

This is illustrated in the following Tables 19.1, 19.2 and 19.3.

More importantly for our discussion, this global growth is expected to go along with a new distribution of capacities worldwide. As evidenced in the tables below, there should be a decrease in Northern America and more significantly, a very sharp decrease in Europe (Northern, Western and Southern) and an increase in all other parts of the world, especially in China and India. Nuclear is predicted to develop in Africa, Latin America, Western, South eastern Asia, and southern Asia even in the high scenario in Oceania.

Although it would need a detailed analysis of the social, political, economic development prospects of all countries likely to embark into nuclear to assess the vulnerability of the non-proliferation regime in the future, the indication of the new distribution of nuclear worldwide already hints to some obvious challenges that will have to be overcome to maintain a high degree of confidence that the expansion of nuclear will not result in a higher proliferation threat.

Changing technologies—A vast majority of reactors in operation or under construction in the world are Pressurized water reactors (54 under construction) with rather large capacities mostly around 1000 MWe and up to 1600 MWe. There are also some Boiling Water reactors and fewer Heavy water reactors.

Table 19.3 World nuclear electrical generating capacity, GW(e)

Region	2018	2030		2040		2050	
		Low	High	Low	High	Low	High
Northern America	112.6	88	111	64	109	40	113
Latin America and the Caribbean	5.1	6	8	7	14	9	19
Northern, Western and Southern Europe	110.5	75	94	50	88	42	67
Eastern Europe	51.3	52	68	52	80	55	79
Africa	1.9	3	4	3	11	7	15
Western Asia	0.4	8	9	12	19	15	24
Southern Asia	8.5	19	27	32	47	51	84
Central and Eastern Asia	106.2	115	175	132	257	149	304
South-Eastern Asia				1	3	3	8
Oceania							2
World total	396.4	366	496	353	628	371	715

These reactors will likely still be in operation in 2050 but many countries and industries are now working on advanced technologies aiming at smaller and sometimes modular reactors (averaging 300 MWe) based on a more diversified array of technologies (PWR but also environments or needs).

Fabrication technologies will also probably evolve as they do in other areas, using computerized support, using 3D printers for modelling and fabrication purposes, using new materials, and facilitating reproduction of parts and their assembly.

This may help in the production or replication area and represent an additional challenge for the detection of clandestine facilities.

Matching the challenges—To match the upcoming challenges and ensure the efficiency of the non-proliferation regime, policies and actions should be taken in the following areas to

- strengthen the legal/institutional framework
- review the fuel cycle arrangements
- make use of technology evolution
- consider emergency preparedness in the verification system.

The legal/institutional framework—The legal or institutional framework that was consolidated until the beginning of the Twenty-First Century with in particular the adoption of the Additional protocol, represents a solid basis that should not be fragilized by new and possibly attractive initiatives like the recent “Nuclear Ban Treaty”.

Except for Israel, India and Pakistan that never signed the NPT, and Korea that stepped out, NPT is almost a universal Treaty and this is a major achievement.

However, the system would be strengthened by improving the decision-making process within the IAEA and at the UN level. When a case of violation is detected or

even perhaps suspected, appropriate pre-defined actions should be quickly adopted by the international community. This kind of increased agility in reacting to any crisis will need leadership and increased cooperation. For instance, the possibility of retrieving specific nuclear material like HEU or under irradiated spent fuel could be devised as a means to gain time and de-escalate a proliferation attempt.

The universality of the adoption and implementation of Additional Protocols should be pursued.

Once this goal reached, a simplification and a merge of safeguards agreements and APs could facilitate their transparency and implementation.

In connection with the implementation of Additional Protocols and the increased number of countries and possibly less accessible locations where nuclear facilities will have to be safeguarded, the resources of the IAEA devoted to safeguards should keep pace with the growth of the nuclear fleet and be disconnected from the increase of the budget of the three other Departments. This will need political engagement to break the very politicized divide between “western countries” and the Group of 77, proponent of budget sharing. With the access to nuclear of new entrants, and developing countries, there should be some opportunities to have a more successful discussion on this aspect.

To meet the financial and more broadly the resource constraint, regional bodies like Euratom or ABACC could increase their contribution to the IAEA findings through joint inspections and sharing of equipment. They could for instance work under the IAEA responsibility in special cases when there is an urgent need to deploy inspectors to re-establish an inventory or carry out unexpected tasks following an agreement with a country where a situation has been detected. In the future such cooperation could be instituted in case North Korea was willing to get back into the international safeguards system.

In view of the future expansion of nuclear in other parts of the world could specific regional bodies similar to ABACC or using CoEs be in charge of some work and be in turn verified by the Agency?

Increased cooperation between NSG and IAEA could benefit both communities; the NSG could be more sensitized to weaknesses or difficulties in carrying out IAEA’s inspection duties in some countries while IAEA would certainly benefit being informed of denials and of certain contracts.

Lastly, the IAEA should consider boosting existing regional offices or creating new offices in regions where nuclear energy is expanding (Asia) and promote training in national safeguards and security and in non-proliferation culture. This effort should not only address the future national Authorities but also the industry to stimulate exchange of good practices and raise awareness among the actors while promoting a better public acceptance of nuclear energy.

Fuel cycle arrangements—Back in 2005 the IAEA launched a wide-ranging reflection about a multinational approach to the fuel cycle.

Non-proliferation friendly nuclear production and trade or market rules could be devised.

In the perspective of increased quantities of fuel to be produced and then processed/stored worldwide, together with an increased number of countries with only one or a few power plants, new types of arrangements could be discussed.

The idea would not only be to minimize the number of locations where sensitive nuclear facilities could be localized but also under what kind of arrangements the security of supply to “dependent” States would be ensured.

Existing enrichment or reprocessing facilities should be first incorporated in such a network of “secured supply” and when located in NWS, should be subject to IAEA safeguards in perpetuity.

This kind of reflection would entail the participation of governments, industry, possibly NGOs and IGO like WTO.

Indeed, certain world trade regulations might have to be adapted to the needs of a specific nuclear market and elevate non-proliferation considerations as an absolute priority.

The innovative approach, foregoing the right to enrich and reprocess nuclear material that the Emirates agreed to follow in their bilateral agreement with the US was welcomed by many as a progress. Some argue that this should set the standard for any future agreement.

It remains to be seen if this one-sided commitment is the best way to address the non-proliferation concern.

As efficient and more equitable a scheme, might be that a real assurance of security of supply/treatment is given to the state unless such a State starts developing a capacity of its own.

The technology evolution—Although until now, the developments have occurred mainly with LWRs and rather with large and larger capacity reactors, the advent of smaller modular reactors or small and medium reactors (SMRs) and advanced technology systems (e.g. GEN IV) will mean new concepts and different fuel cycles to assess and to safeguards. A greater number of small facilities in different countries, sometimes difficult to access, or with specific features (e.g. the transportable nuclear power plants) will pose increased challenges in terms of resources for the IAEA but will also probably require developing new tools to facilitate safeguards.

An assessment of the safeguardability of three main types of advanced technology-fast reactors, triso fueled and molten salt fuel reactors—in comparison with safeguards applied to LWR was conducted by PGS and NEI³ involving different experts. The report concluded that “all types of reactors presented specific challenges or weaknesses that might require to define a new safeguards approach or that could involve some changing in the design or the development of new tools to facilitate safeguards implementation.”

Safeguards and security by design concepts will need to be implemented during the course of the conceptual phase of these new reactors.

The IAEA should ensure a very efficient technology watch on the general technology advances and be aware of likely advances that proliferators could use to serve their projects and defeat its strategy and current tools.

³<https://partnershipforglobalsecurity.org/advancing-nuclear-innovation/>.

In addition, the IAEA should benefit from the use of novel technologies and keep developing specific equipment, like new detectors, sensors, cameras, trackers, and automated recognition devices that may increase its efficiency; new The use of specific robots, and why not drones to carry out inspections in remote areas should be envisaged.

This will need a legal frameworks and the acceptance of the country where those could be deployed but it could save human resources and be sent in case of emergency or social/political unrest.

A great attention should be devoted to the detection of tampering attempts, or to the cyber attacks on IAEA's and operators' data regarding safeguards and security aspects. Very robust, perhaps redundant systems should be adopted to ensure that no major damage could be inflicted to the IAEA's or the States and operators' barriers to proliferation.

Emergency preparedness—With the climate change phenomenon, natural events or catastrophes are predicted to be more intense and more frequent in the years to come. This will have undoubtedly, many geo-political, and economical consequences. It is predicted to affect more importantly developing regions of the world where nuclear is already expanding or will be deployed. It will certainly affect the security of nuclear facilities and require specific actions in terms of safeguards and non-proliferation.

What were the learnings from the Chernobyl nuclear accident and the consequences of the tsunami on the Fukushima power plant, from a safeguards point of view? How tools and strategies of the IAEA (i.e. the redundancy principle) are resistant enough or reactive enough to ensure that no diversion or theft has taken place during unprecedented, unexpected natural disasters? Should the IAEA perform its own "safeguards stress tests" or assessment of the emergency preparedness structure and needs for adapting the approaches and tools? Increased international cooperation and integration of such learnings in the future concepts might be taken into consideration.

Conclusions—If we look back at the history of nuclear development and nuclear non-proliferation, we can only agree that no system is perfect and complete when designed, that efficient systems can hardly be defined once and for all.

The system has shown a good capacity to react to crises and adapt to an evolving environment.

Recent critical situations have occurred, demonstrating the weaknesses of the regime. Because the political stability of the regime is fragile, because the stake is so high there is little choice but to preserve, and strengthen the system based on the international legal instruments, the NPT and related safeguards agreements.

Continuous improvement of the system, including through political commitments, early voluntary implementation of legally binding texts pending their entry into force, increasing international cooperation is the only way forward.

Involvement of all actors including industry and the civil society, and between sectors will be needed.

To stimulate this “leap forward” of the non-proliferation regime, determined State or group of influential States should take the leadership and propose a bolder, more visionary approach similar to that crafted after World War 2.

The shift from traditional nuclear countries to new comers, will be accompanied by the shift from historical Western/Japanese suppliers to China, Russia or Korea as main suppliers.

Indeed, western nuclear industry is nowadays in a difficult position for different reasons and might disappear (Westinghouse, Areva). This trend will only be accelerated if there is no or only a shrinking domestic demand and no financial scheme to support exports of nuclear facilities.

In this situation new alliances may need to emerge, international cooperation will be needed more than ever not only to adapt the system but more importantly to anticipate changes and be prepared in a timely manner.

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