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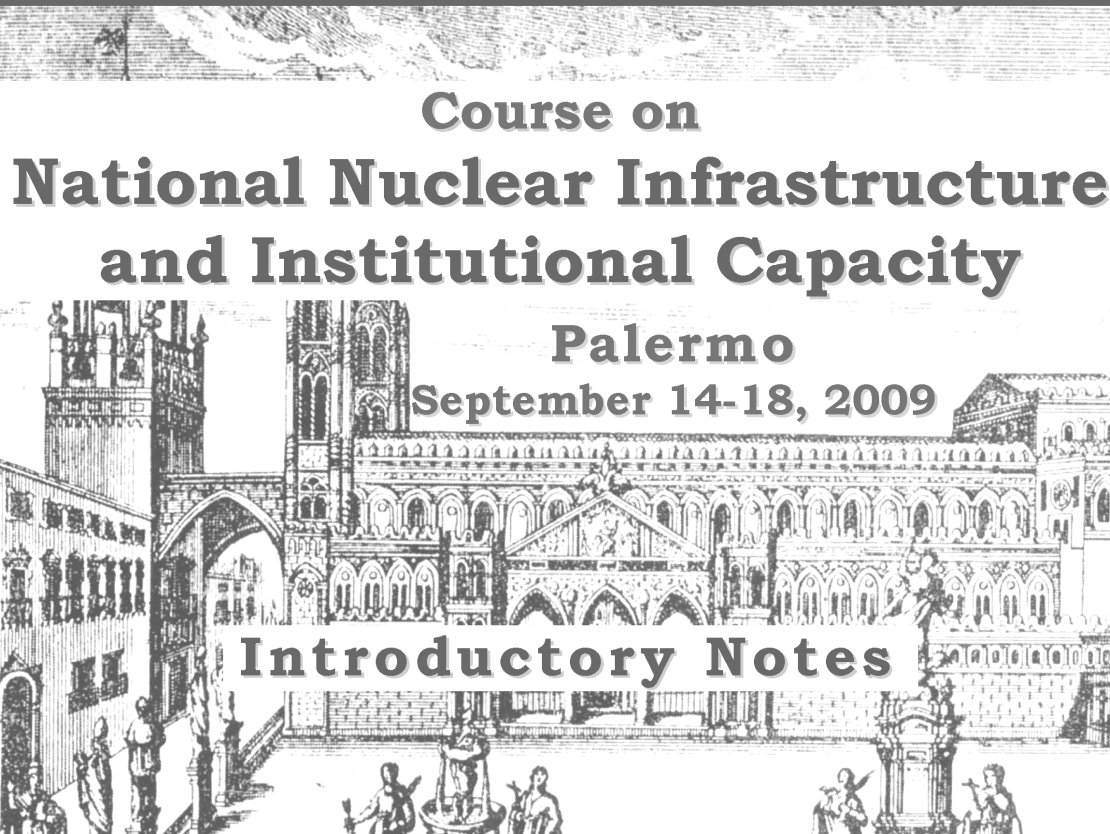
Course on

National Nuclear Infrastructure and Institutional Capacity



Palermo

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Introductory Notes

organized by:

DIN DIPARTIMENTO DI INGEGNERIA NUCLEARE
UNIVERSITA' DEGLI STUDI DI PALERMO

ITER Consult

CIRTEN - CONSORZIO INTERUNIVERSITARIO PER LA RICERCA TECNOLOGICA NUCLEARE

FOREWORD

The course is carried out in the frame of the initiative taken by the Italian presidency of the G8 Nuclear Safety and Security Group (NSSG) to promote an effective cooperation among institutions, academic communities and organizations in order to strengthen the Education & Training and the sharing of best practices for a safe and secure development of a nuclear programme.

Undertaking a nuclear power programme is a major commitment requiring, among others, to fully and adequately address the issue of ensuring nuclear **S**afety, **S**ecurity and **S**afeguards (3Ss) which are prerequisite for a high level of nuclear safety.

The focus of the course is the development of institutional infrastructure: the legal and regulatory framework, the definition of roles and the establishment of appropriate regulatory role, functions and responsibilities.

The course is organized under the auspices of: the Italian Ministry of Foreign Affairs, the Italian Presidency of G8, the EU, the IAEA and the University of Palermo. After an introductory basis, the requirements associated to the process of developing nuclear infrastructure, including lessons learned from experience, are presented and discussed.

The aim is to provide the attendees with a comprehensive view of the key aspects of the process to develop national nuclear infrastructure, to familiarize with requirements for establishing the legal and regulatory framework in compliance with international legal instruments and get an insight into the regulatory role, function and capability.

Acknowledgements

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Antonio Madonna

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1 Introduction

A significant number of countries worldwide have expressed their interest in new nuclear programmes, or expansion of existing programmes.

In countries deciding to consider seriously the use of nuclear energy, the governments need to create the required infrastructure for embarking on a nuclear programme. The infrastructure includes: comprehensive legal framework and obligations at international level, establishment of an effective and independent regulatory system, policies on nuclear waste management and decommissioning.

The International Atomic Energy Agency has issued in 2007 a publication "Considerations to Launch a Nuclear Power Programme" /7/ which addresses the issues to be faced in a country deciding upon and implementing a nuclear power programme. In particular the document analyses relevant factors (12) concerning three sequential phases: a) considerations before a decision is made, b) development before the construction starts and c) subsequent phase related to construction and operation.

Recently new and updated publications of IAEA /1/, /2/, /3/ provide guidance and practical examples for developing national nuclear infrastructure: relevant infrastructure issues (19) are identified and analyzed as referred to three major phases-milestones in the process of development of the national infrastructure.

The IAEA guidance provides also support to undertake specific assessments of country infrastructure status.

In 2008, under the Japanese Presidency of G8 NSSG, attention was paid to provide assistance to countries willing to embark on nuclear power programmes, in establishing an adequate national infrastructure for the attainment of effective levels of the 3Ss (non-proliferation Safeguards, Safety and Security) and in raising the awareness of the importance of the 3Ss, worldwide.

In 2009 the Italian Presidency of G8 has focussed on the importance of the government role in ensuring qualified human resources in the field of safety and security, in particular for education and training, as an essential tool to promote capacity-building at the institutional level in countries embarking on nuclear power, thus contributing to the safe and secure implementation of their nuclear programmes and maintaining high levels of safety and security worldwide.

In this context a one week course on nuclear infrastructure and institutional capacity is organized by ITER-Consult, University of Palermo (DIN) and CIRTEN (Italian Universities Consortium for Nuclear Technological Research) with an emphasis on legal and regulatory framework, definition of roles, establishment of regulatory functions and capacity and focussing on nuclear power plants.

2 BACKGROUND ON NUCLEAR SAFETY & SECURITY

2.1 Historical development of nuclear energy, significant milestones [1]

A short overview of relevant milestones in the historical development of nuclear energy is presented below:

- In 1946 in USA the Atomic Energy Act (AEA) established the Atomic Energy Commission (AEC) to oversee all aspects of atomic energy in US and prohibited private use of atomic energy.

- A licensing procedure for nuclear reactors built by private companies was established in 1956 specifying a 2 steps process.
  In the first step a safety analysis shall be submitted to AEC in order to get a construction permit after approval. In reviewing the safety analysis submitted by the utility, the AEC's regulatory staff was examining the aspects related to the site, the design, the construction specifications, the plan of operations and safety features.

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[1] Milestones in the physics research prior nuclear reactors

- 1895 Roentgen discovered X rays.
- 1896 Becquerel discovered radioactivity.
- 1898 Curies isolated polonium and radium.
- 1899 Rutherford found two kinds of radiation named "alpha" and "beta", emitted from uranium.
- 1900 Villard discovered gamma rays, emitted from radium.
- 1905 Einstein's special theory of relativity *(E = mc2).*
- 1911 Rutherford discovers atomic nucleus.
- 1932 Chadwick discovered neutron.
- 1938 Hahn and Strassmann observed nuclear fission.
- 1942 First nuclear chain reaction.

As second step, after the construction, AEC was conducting an inspection of the NPP to verify that the safety requirements were met and, based on that, it was issued an operating license.

- The safety analysis submitted by the utility was also examined by an Advisory Committee on Reactor Safeguards (ACRS) who was providing recommendations which were taken under consideration by AEC Commissioners.

- In the period 1963-1975 a strong competition between General Electric and Westinghouse and nuclear vendors led to increasing size of designs and the orders for NPPs in USA sharply increased from 4 in 1965 to 31 in 1967.

- During this time the first NPPs were built in Europe based on US technology, while in UK gas-graphite technology was developed and led to construction of many units in UK and outside. Italy was actively reflecting this new technology constructing, during the sixties, three NPPs (GE-BWR, W-PWR and UK Gas-Graphite)

- China Syndrome and ECCS – Great concern was arising in AEC and ACRS from studies that were showing how a LOCA could result in a core meltdown which could lead to the reactor vessel melt-through and reactor containment breach. This scenario became known as "China Syndrome". The main line of defense against such an occurrence would be Emergency Core Cooling System (ECCS) which was designed to dump large quantities of water into the core, to cool the fuel and prevent it from melting.

- The dual and conflicting role of AEC, to promote nuclear power and to regulate safety, was becoming an issue to be resolved. In 1974 the Congress abolished AEC and the Energy Reorganization Act of 1974 created the Nuclear Regulatory Commission (NRC) entering in force on Jan. 19, 1975.

- March 28, 1979 **TMI Accident** (Three Mile Island) has occurred with partial core meltdown at Unit 2 (TMI), due to a series of equipment and human failures. The accident was largely ascribed to operator error, calling into question on

training requirements for reactor operators. In addition, a stuck pressure relief valve was not considered in previous probability studies and fault tree analyses of LOCA. Due to core melt damage the reactor was permanently closed.
Although 25,000 people lived within five miles of the site at the time of the TMI accident, no identifiable injuries due to radiation occurred, and a government report concluded that *"There will either be no case of cancer or the number of cases will be so small that it will never be possible to detect them. The same conclusion applies to the other possible health effects."*

- Following TMI, the NRC established an Office for Analysis and Evaluation of Operational Data to systematically examine the performance of plants and hopefully identify possible problems before they resulted in a major event. An extensive review of design, of safety requirements and of NPP behavior in accident conditions was carried by all involved parties: utilities, designers, regulators. A significant number of "requirements" were identified to be applied to operating NPP in order to increase their safety and their capability to withstand and manage accident conditions.

- After TMI accident 40 nuclear plants which were on order were canceled. TMI accident had serious economic consequence for the US nuclear industry. It also initiated a decline in the public acceptance of the nuclear power technology.

- April 26, 1986 **Chernobyl Accident** - The accident occurred when operators of the power plant ran a test on an electric control system of one of the RBMK reactors. The accident happened because of a combination of basic engineering deficiencies in the reactor and faulty actions of the operators: the safety systems had been switched off and the reactor was operated under improper, unstable conditions, a situation which allowed an uncontrollable power surge to occur. This led to a cascade of events resulting in a series of explosions and consequent fires that severely damaged the reactor building, completely destroyed the reactor, and caused the release of massive amounts of radioactive materials over a ten-day period.

- After the Chernobyl accident, people were exposed to radiation both directly from the radioactive cloud and the radioactive materials deposited on the ground, and through consuming contaminated food or breathing contaminated air. Doses of radiation received during and immediately after the accident were high for some emergency workers, but much lower for later recovery-operation workers and people living in the contaminated areas.
  Because of contaminated milk, the thyroids of many children were heavily exposed to radioactive iodine. Twenty-eight emergency workers died from acute radiation syndrome, 15 patients died from thyroid cancer, and it's roughly estimated that the total number of deaths from cancers caused by Chernobyl may reach 4000 among the 600.000 people that received the greatest exposures.

- After Chernobyl accident a significant effort has been developed by the nuclear industry to review existing design and propose new conceptual design where scenarios of severe accidents, with core meltdown, were taken under consideration and provision were made (design and accident management measures) to cope with such kind of events. Reactor safety has played a significant role in these developments. Safety system based on passive principle have been developed and introduced in the design. Operation has been largely improved. Nevertheless this great effort from industry, and research, to develop new safe conceptual design did not lead to new orders in USA.

- During nineties, after the fall of Soviet-Union, a large effort took place with international cooperation to improve safety of NPPs in operation in Eastern European Countries. A particular effort, still in progress, has been made by EU through dedicate assistance-cooperation programmes.

- Recently the consideration for the use of nuclear energy is entering a new positive phase both in countries operating NPP and in new countries embarking on nuclear for the first time. This new interest depends from many aspects including: increasing energy demand, climate change, economics and security of supply.

2.2 Fundamental Safety Principles

Implementing and achieving nuclear safety means to ensure the protection of workers, people and environment against radiation risk and ensure that the use of nuclear energy does not lead to security or proliferation risk.

Many aspects contribute to nuclear safety and security of a nuclear facility. They have been well identified by IAEA and subject to continuous consideration through the past experience. They include: site selection, NPP conceptual design, construction, commissioning and testing, operation, accident management, emergency preparedness. In addition other aspects are related to: operating procedures (normal and emergency), maintenance programmes, application of PSA, maintaining and reinforcing the safety culture, lesson learned form operation and experience, safety culture, etc.

This understanding of nuclear safety is internationally agreed upon and reflected in the Fundamental Safety Principles issued in 2006 by the IAEA (IAEA Safety Standards N. SF-1).

The 10 principles, listed in the box, formulate for the first time a unified philosophy of nuclear safety and protection against ionizing radiation with a broad international consensus. Safety principles are ccommonly shared safety concepts stating how to achieve safety objectives.

Fundamental Safety Principles

Principle 1:
Responsibility for safety
Principle 2:
Role of government
Principle 3:
Leadership & Management for safety
Principle 4:
Justification of facilities and activities
Principle 5:
Optimization of protection
Principle 6:
Limitation of risks to individual
Principle 7:
Protection of present and future generations
Principle 8:
Prevention of accidents
Principle 9:
Emergency Preparedness and response
Principle 10:
Protective actions to reduce existing or unregulated radiation risks

The safety principles apply for all facilities and activities and for all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning and operation, as well as decommissioning and final closure.

Publication of the Fundamental Safety Principles was jointly sponsored by the European Atomic Energy Community (EURATOM), the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the International Maritime Organization (IMO), the Nuclear Energy Agency of the OECD (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO).

The Fundamental Safety Principles constitutes the conceptual basis for the IAEA's entire safety standards programme and provides the rationale for its wider safety and security related programme. The Fundamental Safety Principles contain the international agreed nuclear safety philosophy and are drafted in language that is understandable to the non-specialist. The intention is to convey an understandable text with basis and rationale to those at senior levels in government and regulatory bodies who are responsible for making decisions concerning the uses of nuclear energy and radiation sources.

2.3 Safety Objectives and Basic Safety Criteria and Requirements

The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation. To ensure that a NPP is operated and activities conducted so as to achieve the highest standards of safety that can reasonably be achieved, measures have to be taken:

- to control the radiation exposure of workers, of public and the release of radioactive material to the environment;
- to minimize the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
- to mitigate the consequences of such events if they were to occur.

From the fundamental objective derive the **radiological safety objectives** which are defined in terms of dose limits for workers and population in normal operating condition of the NPP and in other plant conditions (incidents and accidents). To be mentioned the implementation of the ALARA principle aiming at optimizing the level of protection making the *exposure*s 'as low as reasonably achievable, taking into account economic and social factors.

The radiological safety objectives constitute a major input to address the safety design and the safety analysis as their achievement has to be demonstrated.

The basic approach in the safe design of a NPP is based on the **prevention and mitigation criteria,** requiring that all practical efforts must be made to prevent and mitigate accidents. The provisions to achieve such an objective rely on organizational, behavioural and design measures, such as:

- inherent safety characteristics
- safety margins
- active and passive systems, operating procedures and operator actions
- organizational measures
- safety culture aspects

Preventing and mitigating the consequences of accidents is part of the **defence in depth** principle. Defence in depth is implemented through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment.

If one level of protection or barrier were to fail, the subsequent level or barrier would be available. When properly implemented, defence in depth ensures that no single technical, human or organizational failure could lead to harmful effects, and that the combinations of failures that could give rise to significant harmful effects are of very low probability.

The independent effectiveness of the different levels of defence is a necessary requirement of defence in depth.

Finally the safe and secure operation of a NPP is the result of the combination of the following provisions:

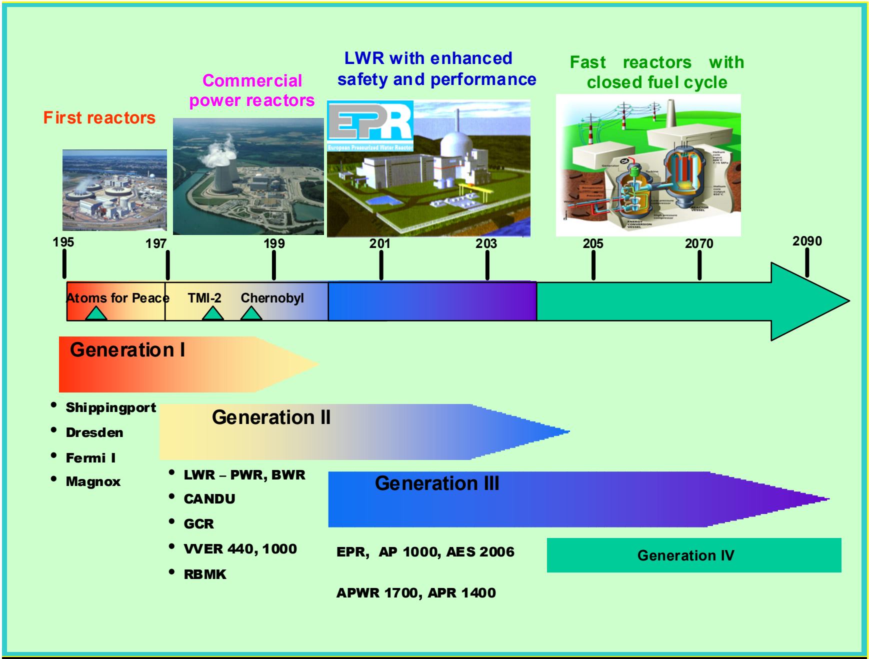
- adequate site selection;
- good design and appropriate engineering features providing safety functions, safety margins, diversity and redundancy, mainly by the use of:
  - an effective quality management system during all phases from siting, design construction, commissioning and operation;
  - an effective NPP management system with a strong commitment to safety and safety culture;
  - an effective and comprehensive set of operational procedures and practices as well as accident management procedures.

2.4 Current status of power reactor designs and their safety features

A significant effort has been made in the last two decades to review the existing design and to propose new conceptual design where the safety requirements are strengthened both at the level of conceptual design (passive and inherent safe design provisions) and at level of analysis of NPP response in accident conditions up to scenarios including so called severe accidents, with core meltdown. To cope with those scenarios, provisions have been made at kevel of design and at level of accident management.

Nuclear reactor designs have evolved over several generations. Below is a brief description of each of these generations:

Generation I reactors date back to the 1950s and 1960. Most generation I reactors tended to be the “first of a kind” prototype designs, such as the Fermi I fast breeder reactor operated from 1957 to 1972. This first generation of reactors was less economical, less resilient and produced more radioactive waste than the subsequent generations of reactors. The Magnox reactors still operating in the UK are the only remaining Generation I reactors and are quickly approaching the end of their operating lives.

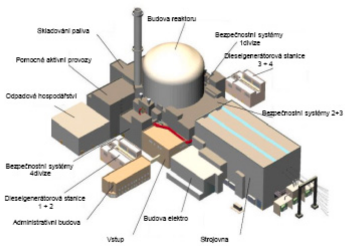


Generation II reactors date from the 1960s through the early 1990s and were the first to be used for large, commercial-scale power generation applications. Most of the reactors in service today are Generation II reactors and include PWR, CANDU, BWR, AGR, and VVER technology. The Generation II reactors where designed and built according to a set of design principles defined on the basis of experience and lessons learned with the Generation I reactors.

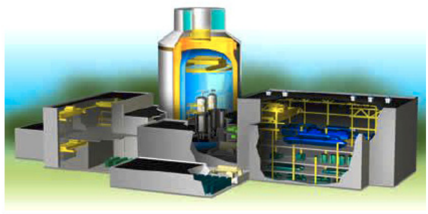
Generation III - The first Generation III reactor (ABWR) began commercial operation at Kashiwazaki-Kariwa (Japan) in 1996. Generation III reactors tend to have standardized designs and mass produced parts, resulting in reduced certification/licensing, design and installation costs. Compared to the Generation II reactors, Generation III reactors are more efficient, benefit from enhanced passive safety systems and produce less radioactive waste.

Generation III+ - It refers to designs offering significant improvements in safety and economics over the Generation III advanced reactor designs certified by the NRC in the 1990s. It includes Advanced CANDU Reactor (ACR), AP1000 - based on the AP600 with an increased power output, European Pressurized Reactor (EPR), VVER-92 (or AES 2006), ESBWR - based on the ABWR.

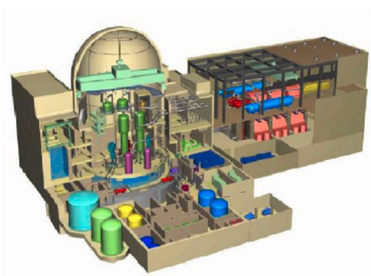
Generation IV reactors are a set of 6 theoretical nuclear reactor designs currently being researched and developed. They are expected to provide a range of benefits including improved safety, improved proliferation resistance, reduced radioactive waste and natural resource utilization, and decreased construction and operation costs.



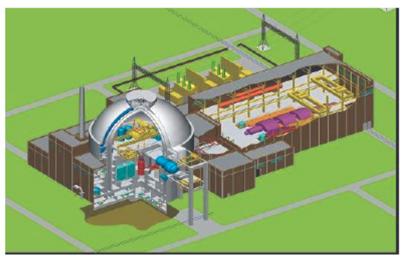
EPR



AP-1000



Mitsubishi-APWR



VVER-92 (or AES 2006)

2.5 Radioactive Waste Management and Decommissioning issues

The use of nuclear energy leads to production of radioactive waste (RW) and later to decommissioning activity of the nuclear facility. These aspects shall be considered since the beginning of national decision to embarking on nuclear programme.
This means that the design and operation of a NPP shall consider the construction of necessary facilities for RW management (treatment and storage) in addition to the spent fuel storage.
In addition the management of the RW and spent nuclear fuel, generated as a consequence of the peaceful use of nuclear energy, need to be managed according to a predefined national policy and strategy.

The policy and strategy includes among others the provision for creation of necessary funds for decommissioning and also for RW management. Depending on the level of infrastructure development, it can be envisaged the creation of dedicated national agency having the responsibility to coordinate the activity for RWM, also in view of disposal strategy, and to harmonize the national legislation with international legislation and standards.
The policy and strategy in the field of management of radioactive waste shall make reference to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

2.6 Safety Culture

In general terms, the safety of a nuclear installation can be understood as the ability of the installation's systems and its personnel to prevent accidents from occurring, or should one occur, to mitigate its consequences.
This implies that nuclear safety is achieved as a result of a number of complementary and overlapping provisions:

- Attention to all the design and construction safety aspects (siting, robust and proven design, high quality manufacturing and construction and comprehensive testing prior to operation, etc.).

- Ensuring that multiple protections (called engineered barriers) are provided to prevent any initial fault or failure resulting in an accident. This is the well known concept of ‘’defence in depth”.
- Establishing and maintaining appropriate ‘’safety culture” at level of management and of individuals.

The term ‘’safety culture” was first used in IAEA publication soon after Chernobyl accident. The safety culture is one of key topics of nuclear safety.

The safety culture of an organization is the product of the individual and group values, attitudes, competences, and ways of behavior that determine the safety management in the organization. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures.

The ‘’safety culture” is the necessary full attention to safety matters as policy of the organization and as dedication of all individuals engaged in the activity.

According to IAEA INSAG 4 /38/ the definition of safety culture is as follows: “Safety Culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.”

Safety Culture can also be defined as “An organization’s values and behaviors - modeled by its leaders and internalized by its members - that serve to make nuclear safety the overriding priority”. Implied in this definition is the notion that nuclear power plants are designed, built, and operated to produce power in a safe, reliable, efficient manner; that the concept of safety culture applies to every employee in the nuclear organization, from the board of directors to the individual contributor; that the focus is on nuclear safety, although the same principles apply to radiological safety, industrial safety, and environmental safety; and that nuclear safety is the first value adopted at a nuclear station and is never abandoned.

From various studies it appears clear that the factors characterizing organizations with a positive safety culture include:

- importance of leadership and commitment of the top management
- clarity of expectations and commitment at all levels
- involvement of all employees
- effective communication and commonly understood and agreed goals
- good organizational learning and responsiveness to change
- full attention to workplace safety and process safety
- questioning attitude and rigorous approach of individuals
- maintenance of knowledge and competence
- effective internal auditing and scrutiny arrangements

3 DEVELOPPING NATIONAL INFRASTRUCTURE

A nuclear power programme is a major undertaking requiring careful planning, preparation and investment in time and human resources. While nuclear power is not alone in this respect, it needs special consideration because of the issues associated with the possession and handling of nuclear material.
The development of a nuclear power programme entails attention to many safety and interrelated issues over a long duration. The introduction of a nuclear power programme involves a commitment of at least 100 years to maintain a sustainable national infrastructure through operation, decommissioning and waste management and disposal.

The decision to implement a nuclear programme needs to be based on the commitment that the use of nuclear energy is carried out in a peaceful, safe and secure way and in accordance with a global nuclear safety regime.
This commitment can be sustained if the country, adopting or expanding nuclear power programmes, has established a national nuclear infrastructure that provides governmental, legal, regulatory, managerial, technological, human and industrial support for the nuclear programme throughout its life cycle. In addition it shall be shown the compliance with international legal instruments, internationally accepted nuclear safety standards, security and safeguards requirements in establishing a responsible nuclear power programme.

The infrastructure needed to support the implementation of a nuclear power plant covers a wide range of tools: legal and regulatory framework, human and financial resources, competence, education & training, regulations, emergency preparedness, transport of the material, the site itself, and the facilities for handling the radioactive waste material.

The activities necessary, and issues to be considered, for development of infrastructure, are extensive and need time and economical resources. They need to be planned and developed since the beginning of the process to decide about adoption of nuclear programme.
Experience has shown that early attention to all the infrastructure issues can facilitate the settlement of future issues and may significantly affect the successful introduction of nuclear power in a country.

Moreover it has to be considered that nuclear power projects have a long duration of development and implementation and it is necessary for the government to provide assurances through policy and legislation that the long term interests of the investors are not adversely affected by political changes.

3.1 Phases and Milestones

The activity to be performed while undertaking a nuclear power programme covers different phases and the decision to move from one phase to the subsequent one needs to be made with a full understanding of the requirements, risks and benefits.

In fact the decision to move to next phases implies significant increase in the commitment of resources.

The IAEA Milestones publication /1/ identifies three distinct phases in the introduction of a nuclear power programme:

- <u>phase 1:</u> covers the preparatory work and assessment in order to make a decision about a potential nuclear power programme;
- <u>phase 2:</u> covers the development of the infrastructure issues required to be ready to begin the industrial activity and to supervise the construction of a nuclear power plant;
- <u>phase 3:</u> covers the construction of the plant up to the approval for commissioning and operation.

The infrastructure development process for each phase leads to the achievement of corresponding milestones as summarized below:

Phase	Activities	Milestones
1	Considerations before a decision to launch a nuclear power programme is taken	Commitment to a nuclear programme
2	Preparatory work for the construction of a NPP after a policy decision has been taken	Invite bids for the first NPP
3	Activities to implement (design, manufacturing, construction) the first NPP	Ready to commission and operate the first NPP

The period of time elapsing for the achievement of the third milestone is estimated by IAEA analyses in 10 – 15 years.

To be underlined the need, during the process above, to have available adequate, skilled manpower in the nuclear energy field. This is a key issue and the related concern has been highlighted by OECD-NEA in October 2007 with adoption by the Steering Committee of a statement on the need of qualified human resources /10/, /20/.

The start of a nuclear power programme requires strict attention and commitment to nuclear safety and security, to radiation safety and to the control of nuclear material.

It has to be commonly shared the basis that this commitment is a responsibility not only to the citizens of the country developing such a programme, but also to the international community.

3.2 Factors to be considered for each milestone

Making reference to the identified tree milestone the major factors to be considered during the infrastructure development are summarized below.

MILESTONE 1: **Ready to make a commitment to a nuclear programme**

A country shall first assess its energy needs and therefore the nuclear power as a possible option to meet some of these needs.

It is important to have a clear understanding of the potential role and appropriateness of nuclear power in the long term energy plan and in the context of the national and socioeconomic development.

These considerations will include also the possibility of installing a nuclear power plant on the national grid network, recognizing that it is usually accepted that no single electric power producing unit should account for more than 5–10% of the installed capacity of the regional electricity network to which it is connected, although notable exceptions do exist.

During the first phase the government, and its support organization, should develop a complete understanding of the obligations and commitments associated with the use of nuclear power before a firm decision to develop a nuclear power programme is taken. Potential for international cooperation should also be taken into consideration.

The needed infrastructure (legal framework, nuclear technology management, waste management, transport, funding, ...) shall be analyzed and the requirements for compliance with international legal instruments and standards taken into account.

In order to verify that the owner/operator obligations can be properly carried out, consideration related the effectiveness of their management system and staff capabilities need to be elaborated.

Additionally, preliminary discussions with potential nuclear system vendors should be conducted to ascertain their interest in, and possible concerns or limitations for, participating in the development of a nuclear power programme and in the supply of a nuclear power plant.

In this phase assistance from IAEA can be received in assessing the needs and requirements to build up the necessary infrastructure for a nuclear power programme.

The conclusion of phase 1 would lead to the attainment of milestone 1 consisting in the political decision to commit to introduce a nuclear power programme in the country.

MILESTONE 2: **Ready to invite bids for first NPP**
Following the policy decision to proceed with the development of a nuclear power programme, the activity for achieving the necessary level of technical and institutional competence should be undertaken. This is the content of the second phase that requires a significant and continuing commitment from the government to develop and establish the required infrastructure needed to select, license, construct and operate a nuclear power plant. The nuclear law need to be established or amended, the regulatory body needs to be developed to a level at which it can fulfil all of its oversight duties. The necessary infrastructure should be developed to the point of complete readiness to request a bid, assess technology and enter into a commercial contract.

The owner/operator (or utility) has a key role at this time, ensuring that it has developed the competence to manage a nuclear project, to achieve the level of organizational and operational culture necessary to meet the regulatory requirements.

During this phase in parallel with the infrastructure development a technical assessment is carried out of possible options, as basis for selection of the NPP technology, design, construction and operational characteristics. This assessment will aim at identifying the following aspects:

- Plant size and characteristics
- Safety conception
- Proven Technology and licensibility
- Standardization
- Simplification
- Constructability
- Operability and manoeuvrability
- Inspectability and maintainability
- Availability
- Plant life time
- Physical Protection
- Decommissioning
- Capital, operation and maintenance cost
- Project schedule
- Degree of national participation
- Technology transfer and technical support
- Refuelling cycle

MILESTONE 3: **Ready to commission and operate the first NPP**

The third phase in the development of nuclear power programme consists of all the activities necessary to implement the first nuclear power plant: that is the construction. The work on infrastructure development is well advanced at this stage which is characterized by important capital expenditures and for that reason close attention by all involved organizations is necessary.

During this phase the owner/operator will develop from an organization capable of ordering a nuclear power plant to an organization capable of accepting the responsibility for commissioning and operating a NPP.

This will require significant development and training for all levels of staff, and the demonstration that the owner/operator can manage the project throughout its life.

While achieving the third milestone is a major accomplishment, it should be remembered that it is only the beginning of a lasting commitment to the safe, secure and effective operation of nuclear power plants.

3.3 Relevant infrastructure issues

Essential parts of a national infrastructure are: the legislation and regulations; the regulatory authority empowered to authorize, to inspect and to enforce; the financial resources; the organizational and managerial resources, the competence and adequate number of trained personnel.
The infrastructures must also provide ways and means of addressing societal concerns which extend beyond the legal responsibilities of the licensee/operator (i.e., the preparation for emergency, the monitoring of radioactivity in the environment, the RW management and the strategy for RW disposal).
Other relevant aspects deal with the industrial, procurement and management issues.

The IAEA has identified 19 relevant infrastructure issues which need to be addressed before a plant is built. These issues include to have in place: an adequate legislative, regulatory, safety, environmental and safeguards regime, an appropriate financing scheme for building, decommissioning and waste management, a fuel cycle strategy, development plans for Human Resources, stakeholder involvement, an appropriate electricity grid. Namely the following 19 infrastructure issues need to be considered:

1. National position
2. Nuclear safety
3. Management
4. Funding and financing
5. Legislative framework
6. Safeguards
7. Regulatory framework
8. Radiation protection
9. Electrical grid
10. Human resources development
11. Stakeholder involvement
12. Site and supporting facilities
13. Environmental protection
14. Emergency planning
15. Security and physical protection
16. Nuclear fuel cycle
17. Radioactive waste
18. Industrial involvement
19. Procurement

Each issue is important and requires a careful consideration. Depending on the perspective, the different issues can have different relevance.
For example, from a legal standpoint the legal framework is the most important issue. From a safety perspective the regulatory framework and nuclear safety predominate. From an economist's perspective, the funding and financing issues are likely to be the prime considerations.

Similar considerations could apply for safeguards or security, or the other areas.

Different organizations, as part of the infrastructure will consider the issues relate to them and address them with the highest priority.

The three major organizations, i.e. government, owner/operator and regulatory body, need to ensure that there is awareness of all these issues.

3.4 Role of vendor country for the infrastructure development

Stated that development of nuclear infrastructure is a national responsibility, the role of the vendor country in supporting the development of national infrastructure is not negligible.

Since the first decade of development of nuclear energy during the sixties the role of the vendor was considerably relevant in providing support to develop the infrastructure in the recipient country. Vendors have always played an important role in E&T in the development and operation of nuclear power programmes.

A recent workshop of IAEA /24/ has ascertained that vendor countries have some moral responsibilities when transferring their technology and have a common interest in providing support to create an adequate safety infrastructure in recipient countries.
Such responsibilities are usually reflected in contractual obligations of the vendor.

Vendor companies should work closely with their national governments to set up agreements to promote nuclear safety in countries seeking to buy their nuclear technology.

The buyer countries should endorse international treaties and conventions, and educate themselves to become "intelligent customers" seeking for long-term safety cooperation covering: reactor design, construction, training, technical assistance, human capacity building, operational and maintenance know-how, experience feedback, and establishment of legal and regulatory infrastructure.

In this process the regulatory authority of the vendor country can cooperate with a view to strengthening the recipient country institutional capacity-building, transferring approaches, information and training to the regulatory body of the recipient countries.

A Build-Own-Operate (BOO) contract approach is currently considered providing the vendor an option to assist in development of infrastructure.

3.5 Evaluation of the status of a national infrastructure

An approach for evaluating the status of a country against each of the infrastructure issues is developed in the IAEA publication for evaluation of nuclear infrastructure development /2/.
It makes reference to the process of reviewing the progresses across all 19 infrastructure issues (listed in par. 3.3) considering their importance and the significant interactions among them. Additional items and requirements could be addressed.

The basis for the evaluation approach comes from the experience and good practices of Member States with developed nuclear power programmes. The objective is to get an integrated view of progress, thereby allowing the country to decide on its readiness to move to the next phase.

Of particular importance is the evaluation of the two early phases of the project (up to the point of declaring the readiness to start the construction of the first nuclear power):

- Achievement of milestone 1 at the end of phase 1 shows that the country has adequately understood the requirements for implementing a safe and successful nuclear power programme and has properly planned and resourced the phase 2 activities.
- Achievement of milestone 2 at the end of phase 2 shows that the country is ready to start construction and regulatory supervision of the first nuclear power plant.

During construction and operation of a nuclear power plant (phase 3) the evaluation of infrastructure development is well established and is based on the fulfilment of Member State obligations to international safety and security conventions and codes of practice, and the application of the IAEA safety standards.

3.6 Roles and responsibilities of major stakeholders

Major stakeholders in launching and implementing a nuclear programme are the Government, the Operator and the Regulator.

Government Role - The government is responsible to establish an effective legal and national framework for nuclear safety and security.

A properly established legal framework provides the basis for the clear assignment of roles and responsibilities and for the regulation of facilities and related activities.

The government is also responsible for the adoption, within its national legal system, of the legislation, regulations, and other standards necessary to fulfil all its national responsibilities and international obligations effectively, and for the establishment of an independent regulatory body.

Governments need to set the regulatory framework such that the regulator has necessary power to control over the various phases from design to operation and decommissioning of a NPP, ensuring the independence of the nuclear regulator from those with the responsibility for the promotion of the nuclear industry.

Finally governments have a responsibility to ensure that the regulators have the competence and resources they need to effectively regulate the industry and deliver the necessary assurance on safety and security.

Government authorities shall also take the appropriate measures and arrangements to ensure emergency preparedness and response, physical protection and security, monitoring releases of radioactive substances to the environment, financial liability, the management of radioactive waste and spent fuel and strategy for RW disposing.

Licensee/Operator Role - The licensee retains the prime responsibility for the safety throughout the lifetime of facilities and activities, and this responsibility cannot be delegated.

This responsibility includes: the management of the facility, the competences, the training, the quality, the safety culture, the safe operation of the NPP, the safe management of generated waste and spent fuel, the information, the emergency preparedness, etc. These responsibilities are to be fulfilled in accordance with applicable safety objectives and requirements as established and approved by the regulatory body.

The licensee is responsible for the licensing process as basis to get the necessary authorizations from the regulatory body during all phases of activities for construction and operation of a NPP.

This responsibility for licensing consists in preparing the required safely analysis reports and submit them to the Regulator. During the evaluation of submitted documentation an effective dialog shall be established between the operator and the licensee to provide the necessary clarification and justification up to the achievement of the authorization and afterwards.

Regulator Role – The Nuclear Regulatory Authority (NRA), established by the Government, has the role and responsibilities for the regulation, the supervision, the inspection of the activity related to the nuclear and radiation safety. These responsibilities can be shared by several state authorities.

The role of the Regulator in the context of nuclear safety and security is to deliver an independent and efficient oversight and control, so that government and public can be assured that their nuclear industry is operating at high levels of nuclear safety and security that are consistent with international standards.

The NRA, according to their statutory functions, can directly license nuclear activities or provides the technical basis for the license (authorization) formally issued by other state institution.

The NRA shall be effectively independent from any organization having responsibility for the promotion of nuclear energy, and should be able to take its safety decisions without pressures from other bodies or governmental organizations. The statutory responsibilities of the regulatory organization should be clearly specified.

The NRA shall be established with necessary requirements regarding: independence, functions, management and organizations, financial resources, staffing, competence, advisory and support organizations.

3.7 National strategy for RWM

Radioactive waste (RW) and spent nuclear fuel generated as a consequence of the peaceful use of nuclear energy, need to be managed according to a predefined national policy and strategy.

Looking at the initial design of past NPP complex and related auxiliary facilities, we can realize that in NPPs built in sixties not much attention was paid to the issue of the RW management. We have NPPs built in sixties where it was not even envisaged a building for the storage of the RW produced during the plant operation. Since that time the issue of RW management and interim storage has received more and more attention, as required, and now it is one key issue to be considered while launching a nuclear program, both in terms of management and also in terms of long term policy for the disposal.

The policy and strategy in the field of management of radioactive waste shall make reference to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management /26/.

The national strategy for RW should focus on the policy for the final disposal and should include the development of:

- national programme for the radioactive waste management;
- appropriate waste management legislation based on advanced international experience;
- national waste management organisations;
- funding mechanisms.

3.8 Emergency Preparedness

Nuclear plants are designed and operated with full attention to safety. The design of appropriate safety features minimizes the probability of radiation release from the plant. However, the probability is not zero and accidents have happened.

The two most serious accidents, Three Mile Island and Chernobyl, demonstrated that emergency planning for the protection of plant personnel, emergency workers and the public beyond the site boundary is a necessary element of the overall plant safety and provides an additional level of defence in depth.

Arrangements must be made for emergency preparedness and response in case of nuclear or radiation incidents /15/, /17/, /18/.

The primary goals of preparedness and response for a nuclear or radiation emergency are:

- to ensure that arrangements are in place for an effective response at the local, regional, national and international levels, to a nuclear or radiation emergency;
- to ensure that, for reasonably foreseeable incidents, radiation risks would be minor;
- to take practical measures to mitigate, for any incidents that do occur, any consequences for human life and health and the environment.

Appropriate branches of government, the licensee, the regulatory body and other involved public institution have to establish, in advance, arrangements for preparedness for, and response to, a nuclear or radiation emergency.

The emergency plan shall be prepared at different levels: onsite, local, regional and national levels and, where so agreed between States, at the international level.

In developing the emergency response arrangements, consideration has to be given to all reasonably foreseeable events.

Emergency plans have to be exercised periodically to ensure the preparedness of the organizations having responsibilities in emergency response.

3.9 Public Communication

While launching a nuclear programme the communication with public deserves a particular attention and shall be conducted appropriately. It is important that the public is fully informed about the rational and reasons behind the introduction of nuclear power, the planned siting of the NPP and the arrangements being made to ensure compliance with the national and international standards and conventions.

Before final decisions are made it is suggested that programmes of public consultation are developed, involving local communities, leaders, politicians, non-governmental organizations and other civil society stakeholders.

In communicating with public the NRA shall build and achieve the public confidence and credibility. It is important that the public has confidence in the communication from the nuclear regulatory authority.

The communication should be transparent and appropriately balanced between openness and necessary confidentiality restrictions. It shall aim to achieve public confidence in particular from the side of the Regulator having an independent function.

Efficiency in decision-making by governmental authorities is increasingly dependent upon public trust. Public communication is one of the keys to the future of nuclear power.

4 LEGAL FRAMEWORK and INTERNATIONAL INSTRUMENTS

The national legal framework in the nuclear field is made of a set of legally binding instruments (legislations and regulations) created to regulate the conduct of nuclear activities. The rules aim to ensure the protection of people and environment from the hazards associated with nuclear activities.

Today in addition to the national framework it exists an international frameworks made of binding and not bindings instruments. The legally binding instruments are treaties, conventions and agreements. The not legally binding instruments are codes, standards, practices, that also contribute to ensure an international nuclear safety & security regime.

Both strong national infrastructures and the international legal instruments are the basis to promote and establish more and more a global nuclear safety regime/11/.

4.1 Basic Nuclear Law

The processes of drafting a national legislation establishing, or revising, a legal framework for the development and use of the nuclear technology and the use of nuclear material are not significantly different from the process of lawmaking in any other field of national interest.

Nuclear energy legislation, like any other legislation, must comply with the constitutional and institutional requirements of each State's political and legal system. However, the subject of nuclear energy is highly complex and technical dealing with some activities and materials posing unusual risks to human health, safety and the environment.

The nuclear law shall regulate the conduct of activities related to the use of nuclear technology and nuclear materials in particular the objective is to provide a legal framework for conducting activities related to nuclear energy and ionizing radiation in a manner which adequately protects individuals, property and the environment.

The basic concepts, often expressed as fundamental principles that shall be covered by the nuclear law include:

The safety principle
The security principle
The responsibility principle
The permission principle
The continuous control principle
The compensation principle
The sustainable development principle
The compliance principle
The independence principle
The transparency principle
The international co-operation principle

The basic reference structure and content of the nuclear law should cover the following items:

- Objectives of the law;
- Scope of the law;
- Definitions of key terms;
- The regulatory authority;
- Authorizations (licensing process and steps, licences, permits, etc.);
- Responsibilities of licensees, operators, users;
- Inspection;
- Enforcement.
- Specific requirements

The specific requirements for each subject area, for example: safety of nuclear installations, radiation protection, emergency preparedness and response, transport, radioactive waste and spent fuel, nuclear liability and coverage, safeguards, mining and milling, radioactive material and radiation sources, export and import controls, and physical protection can be covered in the basic nuclear law or be the content of secondary legislation.

With reference to the content of the nuclear law, it is important to ensure that:

- the terms used are precisely defined in a separate section;
- it is clearly assigned the institutional responsibilities for each regulated activity, and each regulatory authority if more than one, in order to avoid confusion;
- the legislative language is sufficiently clear about which activities are covered and which procedures must be followed in order to comply with the law;

- the legislation contains clear provisions for dealing with disagreements and with violations of regulations (e.g. conflicts of jurisdiction between agencies, appeals by operators against regulatory decisions, punishment of violators of regulations);
- the legislation makes it clear how the financial costs of various activities will be met (e.g. through general tax revenues, license fees or financial penalties for violations);
- the legislation provides for adequate involvement in the regulatory process of stakeholders (including local communities and, where transboundary issues may arise, neighbouring States);
- the legislation contains provisions for the orderly implementation of new or revised arrangements (e.g. a delay period before entry into force or phasing in over an extended period);
- the legislation contains provisions for the treatment of activities being carried out and facilities being operated in accordance with earlier standards (e.g. the exemption of certain activities and facilities from certain requirements (grandfathering)).
- the legislation is consistent with relevant international legal instruments and with international best practice

4.2 Basic Safety Standards

The International Commission on Radiological Protection (ICRP), a non-governmental international scientific organization founded in 1928, has the

objective to establish basic principles and recommendations for radiation protection.
The Recommendations of the ICRP are the main instrument to approach the problems of radiation protection, so they contain the philosophy and the criteria to protect the individual, the population and the environment from the radiation risk. They are periodically reviewed. The most recent Recommendations of the ICRP were issued in 2007.

The Basic Safety Standards (BSS) are international safety standards /13/ specifying the basic requirements for protection of people against exposure to ionizing radiation and for the safety of radiation sources. They reflect knowledge gained and developments in radiation protection and safety. The BSS are based primarily on the recommendations of the ICRP and, in relation to safety, take into account the principles recommended by the IAEA International Nuclear Safety Advisory Group (INSAG).

The BSS are the practical implementations of the Recommendations of the ICRP, and pursue the purpose to establish the basic requirements for protection against the risks associated with exposure to ionizing radiation. They are jointly sponsored by various international organizations and reviewed periodically accordingly to ICRP recommendations.

The BSS aim at achieving harmonization in applying principles, in the development of criteria and standards for radiation protection and in transposing them into regulatory terms.

The BSS cover a broad range of practices and sources that give rise to, or could give rise to, exposure to radiation. The requirements (general requirements, requirements for practices and requirements for interventions) are drafted in general terms and can be fulfilled differently for different types of practice and source, according to the nature of the operations and the potential for exposures.

The principles of radiation protection and safety, on which the BSS are based, are those developed by the ICRP and by the IAEA advisory group INSAG in the area of nuclear safety.

In a simplified way the principles can be summarized as follows:

- a practice that entails or that could entail exposure to radiation should only be adopted if it yields sufficient benefit to the exposed individuals or to society to outweigh the radiation detriment it causes or could cause ***(principle of justification)***;
- individual doses due to the combination of exposures from all relevant practices should not exceed specified dose limits ***(principle of limitation)***;
- radiation sources and installations should be provided with the best available protection and safety measures under the prevailing circumstances, so that the magnitudes and likelihood of exposures and the numbers of individuals exposed be as low as reasonably achievable, economic and social factors being taken into account, and the doses they deliver and the risk they entail be constrained **(*principle of optimization*)**;
- radiation exposure due to sources of radiation that are not part of a practice should be reduced by intervention when this is justified, and the intervention measures should be optimized;
- the legal person authorized to engage in a practice involving a source of radiation should bear the primary responsibility for protection and safety;

- a safety culture should be inculcated that governs the attitudes and behaviour in relation to protection and safety of all individuals and organizations dealing with sources of radiation;
- in-depth defensive measures should be incorporated into the design and operating procedures for radiation sources to compensate for potential failures in protection or safety measures;
- protection and safety should be ensured by sound management and good engineering, quality assurance, training and qualification of personnel, comprehensive safety assessments and attention to lessons learned from experience and research.

4.3 International Legal Instruments (global nuclear safety regime)

International Legal Instruments ensuring a comprehensive international regime on nuclear safety and security are established /11/. They represent a reference for a national regime and are binding for all countries that are party of each of them.

In general terms, the legal instruments aiming at establishing a global nuclear safety and security regime reflects the consensus that emerged following the Chernobyl accident in 1986, which underlined the need for international cooperation to prevent another serious nuclear accident and also the consensus in the area of security after the terrorist attacks of 9/11.

The major new elements of the global regime that have been in place since the mid-1990s are the international legal instruments, such as *Conventions* and *Codes of Conduct*.

The following international legal instruments[2] are in force:

1. Convention on nuclear safety (INGCIRC/449) (1994)
2. Joint convention on the safety of spent fuel management and on the safety of radioactive waste management (INFCIRC/546) (1997)
3. Convention on early notification of a nuclear accident (INFCIRC/335) (1986) and convention on assistance in the case of a nuclear accident or radiological emergency (INFCIRC/336) (1986)
4. Paris Convention on Third Party Liability in the field of nuclear energy (1960) and Amendment protocol (2004)
5. Vienna Convention on Civil Liability for Nuclear damage (1963) and Amendment protocol (1997)
6. IAEA Regulations for the safe transport of radioactive material – 2005 (Safety Std. Series No. TS-R-1)
7. Code of conduct on safety and security of radioactive sources (INFCIRC/663)- 2005
8. Code of conduct on safety of research reactors (GC(48)/7)- 2004
9. Convention on the Physical Protection of Nuclear Material (INFCIRC/274/rev.1)- 1980
10. Amendment to the CPPNM (GOV/INF/2005/10-GC(49)/INF/6)- 2005
11. International convention for the suppression of acts of Nuclear terrorism - UN 2005

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[2] In the European Union, with the objective to give an answer to the need to have a common approach to guarantee the highest level of nuclear safety by establishing binding rules with regard to the safety of nuclear installations, a Nuclear Safety Directive has been adopted on June 25, 2009 by the Environment Council of the EU's Council of Ministers. It represents a major step for achieving a common legal framework and a strong safety culture across the member states.
The directive enhances the role and the independence of national regulatory authorities, confirming the license holders' prime responsibility for nuclear safety. EU member states are also required to encourage a high level of transparency of regulatory actions and to guarantee regular independent safety assessments.

4.4 Compliance with international instruments

The development of a nuclear programme and related legal framework can not be done in isolation. The legislative framework in the country embarking on nuclear power shall be consistent with relevant international legal instruments and with international best practice.

The IAEA plays a key role in this area to support the safe and secure introduction of new nuclear power programmes and providing services to review and assess compliance with international instruments. In this sense, the IAEA has been adapting and continuously improving its existing standards, guidelines and services to better meet the needs of those countries embarking on new nuclear power programmes.

4.5 International Cooperation and Networking

Users of nuclear technology and nuclear regulators need to maintain close relationships with counterparts in other states and with relevant international organizations, since the potential hazards have transboundary impacts.

The practical development of effective international co-operation in the field of nuclear safety had its beginning in the early 1960s and reached a wide-ranging scale in the 1980s and 1990s, after the Chernobyl and Three Mile Island accidents.

Today the international regime of safe development of nuclear energy is based on a system of international legal instruments, international mechanisms, and other intergovernmental structures.

International recommendations, norms, and standards, the implementation of co-ordinated scientific programmes, the exchange of scientific and technological information, the establishment of databases, and the conclusion of international conventions are the subject of a more and more important and essential international cooperation which entails both the regulatory side and the operator side.

The international cooperation, and the use of international experience, is certainly a primary means to support the development of national infrastructure and the development of institutional capabilities in new countries embarking on nuclear power.

In the recent years, supported by international organization, there has been and increased development of information and knowledge management networks for information exchange and co-operation in nuclear safety matters.

This is the outcome of implementation of nuclear conventions, co-operation on safety standards, harmonization of safety approaches, exchange of operational experience and common efforts for the resolution of generic nuclear safety issues.

The IAEA facilitates and promotes international cooperation among its Member States to develop and effectively use high quality safety standards and security guidelines. At the request of its Member

States, the IAEA also provides various peer reviews, advisory services and training events. In addition, the IAEA is the depository of important legally-binding international safety and security *Conventions* and other non-binding international instruments.

5 REGULATORY ACTIVITY & FUNCTIONS

5.1 Regulatory functions

The Nuclear Regulatory Authority (NRA) is established by law in the frame of the national legal framework and shall be responsible for regulation, surveillance and control with respect to all problems relevant to nuclear safety and radiation safety.

Article 8 of the Convention of Nuclear Safety and article 20 of the Joint Convention also require the establishment of the regulatory body to carry out the duties and the responsibilities referred in the conventions with adequate authority, effective independence and resources.

Nuclear regulators play a vital role in the delivery of nuclear safety and security. The operators, quite rightly, have the legal responsibility for safety and security but experience has shown us that this is not enough.

Effective regulators are needed to set the appropriate standards, monitor the performance of the industry and take actions if industry does not meet the required standards.

Nuclear regulators, by their very nature, are law enforcement officers and hence effectiveness is not only related to technical competence but also to legal powers.

If the regulators are effective, then nuclear activities will be seen as safe and secure; the nuclear industry will be committed to sustained excellence in safety and security performance; and the public confidence in the institution will build-up.

The Nuclear Regulatory Authority, to ensure effective performance of its functions, shall:

- have adequate legal authority, technical and managerial competences, and human and financial resources to fulfil its responsibilities;
- be effectively independent from the licensee and other body, so that it is free from any undue pressure from interested parties;
- set up appropriate means of informing the public and other interested parties and the information media about the safety aspects (including health and environmental aspects) of facilities and activities and about the regulatory processes;
- establish international cooperation and networking.

Governments and regulatory bodies thus have an important responsibility in establishing standards and establishing the regulatory framework for protecting people and the environment against radiation risks. The prime responsibility for safety rests with the licensee, however.

The functions of NRA include:

- to develop safety principles and criteria;
- to develop regulations and guidance;

- to establish the licensing process;
- to require operators to conduct safety assessment;
- to conduct the safety evaluation and review of submitted safety analysis from the applicant/operators;
- to require operators to provide any necessary information, even if proprietary;
- to issue, amend, suspend or revoke authorizations and to set necessary conditions;
- to enter in any time sites and facilities to carry out inspections;
- to enforce regulatory requirement;
- to communicate directly with higher level governmental authorities when such access is considered to be necessary to exercise effectively the functions of the body;
- to obtain documents, opinions and external support from private or public organizations or persons, as necessary and appropriate;
- to communicate independently its regulatory requirements, decisions and opinions to the public;
- to liaise with other governmental or non-governmental bodies having competence in such areas as nuclear and radiation safety, environmental protection and security;
- to liaise with regulatory bodies in other countries and international organizations to promote co-operation and exchange of regulatory information.

5.2 Institutional status and organization of NRA

The legal status of NRA depends from many factors like the specific assigned responsibilities, the constitutional and legal system of the country: centralized or federal structure of the state. The Regulatory Body can be part of a Ministry or can be a more autonomous body (e.g. agency) depending from the Ministry or from the Government directly.

In any case it shall be ensured that the functions required can be adequately performed, acting independently from all applicants, licensees or organizations over which it has, or can have, a regulatory responsibility.

If the Regulatory Body consists of more than one regulatory authority, there shall be an effective arrangement to ensure that the regulatory activities are co-ordinated.

The organization of the regulatory body should make adequate arrangements for:

- responding to a nuclear accident or emergency including the availability of an adequate equipped emergency response facility;
- receiving and assessing safety reports related information and data, including the operating experience, from both national and foreign nuclear Operators and feeding back relevant information to regulatory staff and licensees;
- obtaining high level expert review from outside the Regulatory organization on relevant safety matters;
- keeping its staff abreast of the latest safety issues and development.

In addition to ensure regulatory effectiveness retaining appropriate competencies and work approach and organization, internal provisions should be established for:

- self-assessment of the regulatory body performance;
- quality management system;
- effectiveness of inspection techniques;
- use of safety performance indicators;

- communicating risk to the public;
- networking for international cooperation.

5.3 Regulations and Guides

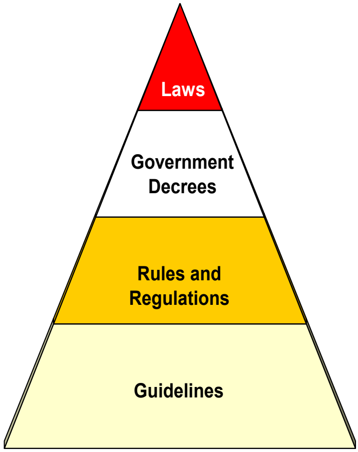
In order to establish the requirements, to which applicants and licensee must comply, and to provide the basis on which to assess the Operator's applications or safety related response, the NRA should establish safety objectives, principles and criteria.

For the interpretation and the correct implementation of the objectives, principles and criteria the NRA can develop regulations and guides. The extent to which such regulation and guides are developed will depend on the existing licensing philosophy, which can be either based on a set of specific detailed provisions (more prescriptive) or on a more flexible approach (less prescriptive).

In developing regulations and guides, the NRA should take into account appropriate national standards as well as international standards among which the IAEA recommendations, codes and guides.
Typical Regulations and Guide refer to the following subjects:

- Safety objectives, criteria and requirements
- Requirements for siting
- Requirements for commissioning
- Radioactive waste management
- Radioactive waste disposal
- Transport of radioactive material and RW
- Decommissioning
- Periodic safety review

- Content and structure of SAR
- Probabilistic Safety Analysis
- Radiation protection
- Quality Management
- etc.



The regulations and guidance from the NRA are part of the so called "*regulatory pyramid*", having at the top the rules/obligation coming from the national law, international treaties and conventions, then the governmental decree's followed by the rules and regulation and the less binding guidelines.

5.4 Size, structure, competence and staff of the NRA

The staff of NRA should be composed of individuals possessing broad technical expertise related to nuclear and radiation safety, to different fields of engineering as applied to NPP and other nuclear facilities, capable of assessing, on an overall basis, the safety of a nuclear installation.

The NRA shall have the capability to establish and effectively manage the licensing process and related technical review and evaluation. The NRA shall have the competences and the skill to achieve the review objectives, to coordinate the review work among different field of expertise, to plan and address priorities and conduct inspection and surveillance activities.

There is no unique recommendation on the size and the structure of the regulatory body but they should commensurate with the nuclear programme. The NRA structure and size may change during various stages:

- development of regulation and guides at the start of the nuclear programme;
- review and assessment of siting and design;
- inspection and enforcement, review and assessment and authorization during construction and operation;
- emergency preparedness before commissioning.

All the members of the Regulatory organization, at all levels, should understand the organization regulatory role, the legal responsibilities and objectives, and how, these are expected to be achieved in practice.

It should be arranged an adequate level of administrative, secretarial and technical support for the regulatory staff to carry out their duties effectively and efficiently. The technical support provisions should include the information, communication and computer facilities.
In additional NRA staff should be kept updated and aware of R&D.

5.5 Elements of regulatory independence

The objective of the regulatory independence is to prevent any undue pressure form interests conflicting with the safety.

The independence of NRA is also a condition to achieve credibility in the eyes of the general public.

The importance of the regulatory independence is affirmed in the IAEA Safety Requirements in terms of need for separation and independence from promoters of nuclear technologies. This is one element affecting the independence of NRA other exist.

Of course, the regulatory body cannot be absolutely independent in all respects, but must have an effective independence, which does not imply adversarial relationship. The independence of the NRA is effectively achieved by ensuring a set of conditions which includes:

- an institutional status which is independent from promotion of nuclear energy and from licensee and operators,
- having statutory power to perform the required functions
- authority to adopt or to develop regulations related to safety
- authority to take decisions including those on enforcement actions
- being not subject to political influence or pressure for safety decisions
- being adequately funded and having independent financial administration.
- having independent technical expertise in areas of responsibility
- having access to independent external technical expertise and advice
- having authority to communicate independently its regulatory requirements, decisions and opinions and their basis to the public
- having authority to liaise with regulatory bodies of other countries and with international organizations to promote cooperation and the exchange of regulatory information

5.6 External support (TSO)

If the NRA is not entirely sufficient in all technical areas, to conduct review and assessment or to develop regulations and guides, it can rely on an external technical support. This external technical support shall be competent and independent from the interests related to the matter subject to the support activity.

This support is normally provided by the "so called" Technical Safety Organizations (TSO) having a public or private legal status. TSOs are gaining an increased importance by providing the technical and scientific support to Regulators for decisions and activities regarding nuclear and radiation safety.

In Europe the concept of TSO has been used for many years. A few years ago a "European TSO Network" (ETSON) has been created. The Memorandum of Understanding (MoU) provides a clear definition of the TSO concept. It includes the requirements of being an independent organization, performing safety assessments with a global regulatory vision, supporting its national nuclear regulatory authority, maintains a high level of competence in nuclear and radiation safety, etc.

When relying on the external technical support to perform the technical review, as the responsibility remains with the NRA, it is necessary that the NRA has the managerial and technical capability to define what is needed, what are the objectives of the review expected from the external organization and the capability to verify the adequacy and correctness of provided results and use them in their internal decision making process.

5.7 Licensing System

The authorization for activities related to nuclear installations, according to safety requirements, is ensured and regulated throughout a licensing system, which can be more or less prescriptive in its approach.

In the more prescriptive approach to regulate nuclear safety, the regulatory organization specifies all of the safety related requirements that the licensee must meet, usually in the form of a detailed statutory regulation and supportive provisions.

Although, compared with a non- prescriptive (or less prescriptive) regime, a highly prescriptive approach to the regulation may simplify the regulatory inspection process and be less demanding in terms of the qualifications and experience required, it can be counter-productive in perspective and in terms of commitment from the applicant/licensee.

In contrast to the approach of specifying in detail what a licensee should do, the less-prescriptive approach establishes mainly safety objectives and requirements allowing the applicant/licensee to adopt and implement the necessary provisions with suitable requirements and to produce a continuous effort to seek for the most achievable benefits.

The licensing process covers the different stages through which the authorizations and licenses are issued for the realization and operation of a nuclear installation up to the end of life, which include in sequence:

♦siting
♦design
♦construction
♦commissioning
♦operation
♦modification
♦periodic safety review
♦decommissioning

It is an ongoing process and the review and assessment activity should proceed from a conceptual phase (overall design) to a detail phase (specific parts and systems) and should begin well in advance of the release of authorization or licensee. The regulatory evaluation and review is performed on the ”safety analysis report” submitted by the applicant in accordance with requirements. The safety analysis report can be supported by design documentation, but shall have in its content the safety analysis and safety justification showing how the safety criteria or requirements have been fulfilled.

The licensing process can envisage that during the evaluation process the NRA shall take into consideration (as advice) the expert opinions provided by an ”Advisory Committee” legally established and composed of independent experts from other public institutions and organizations.

Modification of a nuclear installation can take place as a consequence of the operational experience, or due to technological innovation, or as consequence of nuclear/radiation safety improvements.

If relevant for safety, the modification shall undergo a specific licensing process, and be authorized, before implementation. This directly implies the updating and approval of the revised Safety Analysis Report (living document accompanying the life of the installation)

The NRA can identify conditions and constraints to be imposed on the licensee at any stage in the interest of safety, addressing the key areas relating to the safety of the installation and corresponding to the stage under evaluation (siting, design, construction, commissioning, operation and decommissioning).

For the aspects related to the safety of the operation the conditions can affect:

- plant operational limits;
- operating rules and procedures;
- testing and maintenance procedures;
- plant safety management;
- radiological protection;
- radioactive waste management;
- quality assurance;
- nuclear safety committees;
- safety documentation and reports;
- emergency response and accident management

5.8 Safety Analysis Report

The Safety Analysis Report (SAR) represents the reference document that documents the adequacy of safety analysis to ensure that the facility can be constructed commissioned and operated safely and in compliance with applicable laws and regulations. The SAR is developed by the applicant and contains the necessary description, information, data, safety justification and safety analysis to show the adequate and complete fulfilment of safety requirements.

The safety analysis report, according to predefined structure and content, is submitted (in different versions) to Nuclear Regulatory Authority at the different stages of the licensing process: siting, design, construction, commissioning and operation of the installation.

Concepts of “preliminary”, “intermediate” and “final” Safety Analysis Report (respectively PSAR, ISAR, FSAR) are broadly applied as referred to the stages of authorization for construction, permission for commissioning and license for operation.

SAR re-evaluations are carried out during the operation for plant modifications and periodic safety reviews up to the decommissioning.

Guidance for the format and the content of SAR are given in /36/, /37/.

It has to be underlined the importance of the SAR as the reference document that documents the safety conception, safety measures, safety requirements and safety analysis implemented in the NPP. Therefore it is unique and is the basis for the licensing process and related authorization steps.

The SAR is submitted to the NRA by the Applicant (normally the operator). In the preparation of the SAR the applicant can rely on the support of other organizations but the responsibility for its content in the process of discussion and review with the regulator belongs uniquely to the Applicant.

The respect of the roles and related responsibilities is fundamental in establishing an effective regulatory and licensing framework.

The SAR is updated during the lifetime of the NPP in consequence of safety relevant plant modifications and also in correspondence of periodic safety review of the installation normally carried out every 10 years.

5.9 Review and assessment procedures

The primary purpose of the assessment from the NRA of the SAR (with supporting documentation) is to verify that:

- regulatory safety objectives are met;
- radiation exposures have been minimized;
- the potential for the accident has been minimized;
- accidents are systematically analyzed
- accidents effects are mitigated and limited in terms of radiological consequences
- safety requirements are adequately implemented in the design and operation

To provide for a consistent and uniform approach the NRA shall specify the objectives, the criteria and requirements to be considered during the evaluations of the SAR and make them available to the applicant/licensee.

They cover two major sets:

- limits that must not be exceeded (e.g. radiological safety objectives in terms of dose limits);
- engineering principles, criteria and requirements to be implemented to ensure a high level of safety in all aspects of the design, construction and operation.

The engineering criteria covering fundamental principles, conceptual design, specific design construction and operation activity include the following:

- defense in depth;
- use of proven technology;
- identification of safety functions
- single failure criteria;
- fail-safe design;
- minimized sensitivity of the plant to potential faults;
- design for in-service inspection and maintenance;
- reliability requirements;
- diversity;
- redundancy;
- common cause failure;
- segregation;
- safety classification;
- qualification requirements;
- quality assurance;
- human factor and man machine interface.

The methodologies for evaluating the adequacy of the safety case include both the deterministic approach as well as probabilistic approach.

The deterministic approach can be used in the analysis of Design Basis Accidents (adequately identified in the SAR) to demonstrate the fault tolerant characteristics of the plant, the effectiveness of the safety systems and to verify the limits for the safe operation. Uncertainties are covered by application of conservatism and margin.

Probabilistic Safety Analysis (PSA) provides for a comprehensive and logical analysis of the potential consequences resulting from postulated faults or initiating events and the role played by the safety systems. It can provide a numerical basis for comparing estimated risks and to identify weak points in the design or in the operation (including the accident management guidelines) of the installation. For a NPP three PSA levels can be applied respectively to assess:

- core melt frequency (level 1);
- containment accident response and releases(level 2);
- public health consequences (level 3).

5.10 Licensing Steps

The major stages in a licensing process for a NPP, from the beginning to the end of the installation life, are the following:

- siting;
- design;
- construction;
- commissioning;
- operation;
- plant modification;
- periodic safety review;
- decommissioning.

For each of these stages the NRA will conduct a review of the operator's submitted safety documentation (as required by the licensing procedure) and will release its authorization or license with related condition.

Preliminary Safety Analysis Report, Pre-Operational Safety Analysis Report and Final Safety Analysis Report constitute different progressive version of the Safety Analysis Report prepared at the different stages of the licensing process.

Guidance on format and technical content of SAR are given in /36/, /37/.

5.11 Inspection and Enforcement

The NRA is responsible for regulatory inspections. Regulatory inspection should provide for the systematic verification that licensee conditions, and any other regulatory requirements placed on the licensee in the interest of safety, are being met.

In case the Operator fails to meet his responsibilities, an enforcement action is taken from NRA to ensure that any non-compliance is corrected.

Inspection staff - The effectiveness by which the NRA is able to implement its inspection and enforcement responsibilities is determined, mainly, by the experience and professional competence of the staff. Regulatory inspectors should have a clear understanding of their duties and of the statutory power, which is behind their function.

In addition to the technical qualification, an inspector should have sufficient experience at an appropriate level of seniority to gain respect and also to establish fruitful professional dialogue with responsible people in the licensee organization. An inspector should be familiar with the safety documentation and safety analysis report of the visited installation and should be in contact with the Regulatory body analysts, which are involved in the assessment of the safety of the plant in order to have knowledge of links between inspection and safety analysis issues.

<u>Inspector's authority</u> **-** The degree of authority of the inspector shall be clearly defined and understood by concerned parties.
In some countries the inspector has the authority to enforce the licensee to take immediate corrective actions if there is an imminent and significant risk to the health and safety of workers on the site, or of the public, or of the environmental.
Other countries require such enforcement decisions have to be taken at a more high level within the regulatory organization. In this case the promptness by which the relevant information is received and the regulatory response is determined and transmitted to the Operator to prevent deterioration of safety is important.

<u>Inspection programme</u> **-** The NRA shall prepare a comprehensive and in-depth programme of regulatory inspection for monitoring the management of safety at each nuclear installation and verify that the applicant/licensee is complying requirements. The regulatory inspections programme includes routine and non-routine inspections, announced or

unannounced inspections during all stages of the life of the installation (sitting, construction, commissioning, operation, decommissioning) and may include the inspection of the Vendors involved in the quality assurance programmes.
The inspection programme should be based on different inspection techniques (examination, of documentation, surveillance, personnel interview, tests and measurements) and should indicate the key items (activities, systems, components, technical and administrative procedures, etc) and the frequency of the inspection.

<u>Enforcement arrangements</u> **-** When the licensee fails to meet its statutory responsibility, enforcement actions should be taken to ensure that non-compliance are corrected, that the necessary remedial actions are taken, and that any arrangement envisaged by the law for penalties are taken. The severity of the enforcement actions should be graded to reflect the safety significance of the particular regulatory violations and include:

- written directives or warnings, which specify the nature of the violation and establish a period of time for taking the necessary corrective actions;
- orders to curtail the activities in the case of a clear deterioration of plant systems or condition or in the case of an imminent radiological hazard, consisting in some cases in the reduction of the power or shutdown of the installation;
- revocation of licensee in case of serious non-compliance or undue radiological risk;
- penalties in case, envisaged by the law, for a serious violation and for deliberate non-compliance.

5.12 Role of NRA for the emergence response

The NRA has no direct responsibility for preparing and implementing emergence plans. The on-site emergence plan is in the responsibility of the Operator, while the overall emergence plan is in the responsibility of local and national public authorities, but NRA should assist the public authorities to develop their emergence plans and to maintain their preparedness in cooperation with the licensee.
The NRA has the responsibility to ensure that the individual licensee has established adequate arrangements for responding to any abnormal occurrence or accident, including the submission of formal emergence response plans and the preparation of their exercise. The NRA has also responsibility to review and assess the emergency plan submitted by the licensee.
The Regulatory Body should develop its own internal emergency plan to ensure that there will be an effective response from NRA in the event of an accident.

During an emergency situation, among other responsibilities, as established by the national practice, the NRA should act as the advisor to public authorities and operator with regard to nuclear and radiation safety, monitor the action proposed by the operator, inform the public authorities and the public about the status and the progress of the emergency situation.

5.13 Regulatory Liaison

The Regulatory Body should establish and maintain liaison with other governmental organizations, or administrations, which have responsibilities related to nuclear safety or radiation safety or whose co-operation or support is felt necessary for the regulatory activity.

These liaisons are not only national but also international considered that the nuclear and radiation safety constitute a high priority international issue.

Liaison with governmental organizations - The NRA should have work relations, based on approved procedures and divisions of responsibilities, with those governmental organizations at the national and local level responsible for areas interfacing with the regulation of the nuclear and radiation safety like: land use, geological service, water resource, environmental protection, health and industrial safety, emergency preparedness and civil protection, fire protection, etc.

Liaison with operating organization - An atmosphere of mutual respect and confidence should be established between the Operator and the Regulatory Body. An effective dialogue among these two parties constitute the base to approach and resolve in the most effective way the problems and issues related to the regulatory and surveillance activity and achieve the common goal of safe operation.
The licensee is required to provide the NRA with the information, analysis and justification necessary for

the regulation and control activity including access to the site to inspect or witness operations, maintenance, inspection or tests. Similarly the licensee needs to foresee at each stage the regulatory requirements, which have to be complied with.

Liaison with external technical support and consultants - The NRA, in conducting review and assessments, may establish liaison with external technical support organizations (national and international) to receive support. In this relation it is important that the consulting part is independent from the applicant/licensee or vendor. The use of consultants/support organizations does not relieve the NRA of its responsibilities for making decisions or recommendations.

Liaison with public and media - In performing its activity the NRA is dealing with many issues, some of them may be controversial and of particular interest for the individuals and the society.
In doing that an open and transparent attitude is considered important, ensuring that all persons, communities or organizations that may be affected by a particular regulatory decision are kept informed on the regulatory policy and related facts.

With reference to regulatory issues of general public interest, or to matters of particular public concern, liaison arrangements should be established with the public and the media for the provision of factual information (and information material) related to nuclear safety, explaining in non-technical language how NRA is carrying out its responsibilities.

5.14 International Cooperation

The nuclear safety is of international concern. Therefore, the NRA with support of national institutions, as appropriate, should consider the establishment of arrangements for the exchange of information both on bilateral level with neighbouring and other interested countries and with the wider international community.

The purpose of these arrangements should be, inter alia, to promote the exchange of regulatory and technical information on nuclear safety as well as early notification of nuclear accident and mutual assistance in accordance with international conventions in these areas.

In the recent years, supported by international organizations, there has been and increased development of exchange of information and co-operation in the international community.

The IAEA facilitates and promotes international cooperation and, at the request of its Member States, provides services for peer reviews (e.g., the Integrated Regulatory Review Service (IRRS)).

5.15 Funding of NRA

Adequate funding of NRA should be ensured and established by law. The Government is responsible for deciding how the NRA should be funded.

The funding arrangement can be based on direct grant from the Government or on payment of a fee by the operating organization or on a combination of them. The funding of NRA shall cover also the cost of technical studies, assessment and expert-review, which are committed to external technical support organizations or consultants.

Appendix A

STRUCTURE OF IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish standards of safety for protection against ionizing radiation and to provide for the application of these standards to peaceful nuclear activities.

The regulatory related publications by means of which the IAEA establishes safety standards and measures are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (that is, of relevance in two or more of the four areas), and the categories within it are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides:**

Safety Fundamentals (**blue lettering**) present basic objectives, concepts and principles of safety and protection in the development and application of nuclear energy for peaceful purposes.
Safety Requirements (**red lettering**) establish the requirements that must be met to ensure safety. These requirements, which are expressed as 'shall' statements, are governed by the objectives and principles presented in the Safety Fundamentals.
Safety Guides (**green lettering**) recommend actions, conditions or procedures for meeting safety requirements. Recommendations in Safety Guides are expressed as 'should' statements, with the implication that it is necessary to take the measures recommended or equivalent alternative measures to comply with the requirements.

The IAEA's safety standards are not legally binding on Member States but may be adopted by them, at their own discretion, for use in national regulations in respect of their own activities. The standards are binding on the IAEA in relation to its own operations and on States in relation to operations assisted by the IAEA.
Information on the IAEA's safety standards programme (including editions in languages other than English) is available at the IAEA Internet site:

www.iaea.org/ns/coordinet

or on request to the Safety Co-ordination Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.

OTHER SAFETY RELATED PUBLICATIONS

Under the terms of Articles III and VIII.C of its Statute, the IAEA makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its MSs for this purpose.
Reports on safety and protection in nuclear activities are issued in other series, in particular the **IAEA Safety Reports Series**, as informational publications. Safety Reports may describe good practices and give practical examples and detailed methods that can be used to meet safety requirements. They do not establish requirements or make recommendations.
Other IAEA series that include safety related sales publications are the **Technical Reports Series,** the **Radiological Assessment Reports Series** and the **INSAG Series**. The IAEA also issues reports on radiological accidents and other special sales publications.
Unprized safety related publications are issued in the **TECDOC Series**, the **Provisional Safety Standards Series**, the **Training Course Series,** the **IAEA Services Series** and the **Computer Manual Series**, and as **Practical Radiation Safety Manuals** and **Practical Radiation Technical Manuals.**

Appendix B

ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AGR	Advanced Gas Reactor
ALARA	As Low As Reasonably Achieved
AP	Advanced Pressurized
BOO	Build-Own-Operate
BSS	Basic Safety Standards
BWR	Boiling Water Reactor
CANDU	CANadian Deuterium Uranium reactor
CIRTEN	Consorzio Interuniversitario per la Ricerca Tecnologica Nucleare
CPPNM	Convention on Physical Protection of Nuclear Material
DBA	Design Basis Accident
DBE	Design Basis Event
DIN	Dipartimento di Ingegneria Nucleare
EC	European Commission
ECCS	Emergency Core Cooling System
EPR	European Pressurized Reactor
ESBWR	Economic and Simplified BWR
EU	European Union
ETSON	European Technical Safety Organization Network
EU	European Union
GE	General Electric
HR	Human Resources
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
INSAG	International Nuclear Safety Group
IRS	Incident Reporting System
IRRS	Integrated Regulatory Review Service
ITER	Independent Technical Evaluation and Review
LOCA	Loss Of Coolant Accident
LCO	Limits and Conditions for the Operation
MoU	Memorandum of Understanding

MS	Member State
NPP	Nuclear Power Plant
NEA	Nuclear Energy Agency
NF	Nuclear Facility
NRA	Nuclear Regulatory Authority
NRC	Nuclear Regulatory Commission
NSSG	Nuclear Safety and Security Group
PSA	Probabilistic Safety Assessment (Analysis)
PWR	Pressurized Water Reactor
RBMK	Reaktor Bolshoy Moshchnosti Kanalniy (High Power Channel Type Reactor)
R&D	Research & Development
RW	Radioactive Waste
RWM	Radioactive Waste Management
SAR	Safety Analysis Report
TMI	Three Mile Island
TSO	Technical Safety Organization
UK	United Kingdom
UN	United Nations
US	United States
VVER	Vodo-Vodyanoi Energetichesky Reactor (Water-Water Energetic Reactor)
W	Westinghouse

Appendix C

GLOSSARY

Applicant / Operator - A *legal person* who applies to a *regulatory body* for *authorization* to undertake specified *activities*. Strictly, an *applicant* would be such from the time at which an application is submitted until the requested *authorization* is either granted or refused. Once received the authorization and the activity is started the Applicant becomes and Operator.

Basic Safety Standards (BSS) – Basic international safety standards that specify the basic requirements for protection of people against exposure to ionizing radiation and for the safety of radiation sources. They reflect knowledge gained and developments in radiation protection and safety. The BSS are based primarily on the recommendations of the ICRP and, in relation to safety, take into account the principles recommended by the International Nuclear Safety Advisory Group (INSAG).

Commissioning - The process during which nuclear power plant components and systems, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria. Commissioning include both non-nuclear and nuclear tests.

Decommissioning - Administrative and technical actions taken to allow the removal of some or all of the *regulatory controls* from a *facility. Decommissioning* typically includes dismantling of the facility but not necessarily. A facility could, for example, be *decommissioned* without dismantling and the existing *structures* subsequently put to another use (after *decontamination*).

Decommissioning actions are taken at the end of the *operating lifetime* of a *facility* to retire it from service with due regard for the health and *safety* of workers and *members of the public* and the *protection* of the environment.

Defence in depth - A hierarchical provision of different levels of safety features and procedures to prevent the escalation of anticipated operational occurrences and to maintain the effectiveness of physical barriers placed between a radiation source or radioactive material and workers, members of the public or the environment.

Design Basis Events (Accidents) - The range of conditions and *events (accidents)* (DBE, DBA) taken explicitly into account in the *design* of a *facility*, according to established criteria, such that the *facility* can withstand them without exceeding *authorized limits* by the planned *operation* of *safety systems*.

Deterministic analysis - *Analysis* using, for key parameters, single numerical values (taken to have a probability of 1), leading to a single value for the result. Typically used with either 'best estimate' or 'conservative' values, based on expert judgment and knowledge of the phenomena being modeled.

Dose limit - The value of the *effective dose* or the *equivalent dose* to individuals from controlled *practices* that shall not be exceeded.

Emergency preparedness - The capability to take actions that will effectively mitigate the consequences of an *emergency* for human health and *safety*, quality of life, property and the environment.

Equipment qualification - Generation and maintenance of evidence to ensure that equipment will operate on demand,

under specified service conditions, to meet system performance requirements.
More specific terms are used for particular equipment or particular conditions; for example, **seismic qualification** is a form of equipment qualification that relates to conditions that could be encountered in the event of earthquakes.

Intervention. Any action intended to reduce or avert *exposure* or the likelihood of *exposure* to *source*s which are not part of a controlled *practice* or which are out of control as a consequence of an accident.

License - A legal document issued by the *regulatory body* (or other state institution) granting *authorization* to perform specified *activities* related to a *facility or activity*. The holder of a current *license* is termed a ***licensee***.

Licensing process – The authorization process to get the license.

Nuclear safety - The achievement of proper *operating conditions* of a facility, prevention of *accidents* or mitigation of *accident* consequences, resulting in *protection* of *workers*, the public and the environment from undue *radiation* hazards.

Nuclear security - The prevention and detection of, and response to, theft, *sabotage*, unauthorized access, illegal transfer or other *malicious* acts involving *nuclear material*, other *radioactive substances* or their associated *facilities*.
In general, *security* is concerned with *malicious* or negligent actions by humans that could cause or threaten harm to other humans; *safety* is concerned with of harm to humans (or the environment) deriving from the operation of facility and related potential malfunctioning or internal or external accidents.

Operation - All activities performed to achieve the purpose for which a nuclear power plant was constructed. For a nuclear power plant, these include maintenance, refuelling, in-service inspection and other associated activities.

Operational limits and conditions - A set of rules setting forth parameter *limits*, the functional capability and the performance levels of equipment and personnel approved by the *regulatory body* for safe *operation* of an *authorized facility*.

Periodic Safety Review - A systematic reassessment of the *safety* of an existing *facility (or activity)*carried out at regular intervals to deal with the cumulative effects of *ageing*, modifications, operating experience, technical developments and *siting* aspects, and aimed at ensuring a high level of *safety* throughout the *service life* of the *facility (or activity)*.

Practice - Any human activity that introduces additional *sources* of *exposure* or additional *exposure pathways*, or extends *exposure* to additional people, or modifies the network of *exposure pathways* from existing *sources*, so as to increase the *exposure* or the likelihood of *exposure* of people or the number of people exposed.

Probabilistic safety assessment (PSA) - A comprehensive, structured approach to identifying *failure scenarios*, constituting a conceptual and mathematical tool for deriving numerical estimates of *risk*.

Quality assurance (QA) - Planned and systematic actions necessary to provide adequate confidence that an item, *process* or service will satisfy given *requirements* for quality.

Risk assessment - Assessment of the radiological risks associated with normal operation and possible accidents of nuclear facility or other authorized practice. This will normally include *consequence assessment*, together with some assessment of the *probability* of those consequences arising.

RW Disposal - Emplacement of *waste* in an appropriate *facility* without the intention of retrieval.

RW Storage - Emplacement of *waste* in an appropriate *facility* with the intention of retrieval.

Radioactive Waste Management - All activities, administrative and operational, that are involved in the handling, transport, pre-treatment, treatment, conditioning, storage, and disposal of waste from a nuclear facility.

3Ss – Safety, Security, Safeguards

Safeguards - Nuclear safeguards are measures to verify that civil nuclear materials are properly accounted for and are not diverted to undeclared uses. The measures include nuclear materials accountancy, containment and surveillance.

Safety Analysis, Safety Assessment - The *process* and result of a study aimed at understanding the subject of the *analysis*, while *assessment* may also include determinations or judgments of acceptability. *Analysis* is also often associated with the use of a specific technique. Hence, one or more forms of *analysis* may be used in *assessment.*

Single failure criterion - A criterion (or requirement) applied to a system such that it must be capable of performing its task in the presence of any single failure.

Siting – Activity corresponding to the phase of selection, and approval, of a site for a nuclear facility. It involves the analysis of those factors at a site that could affect the safety of a facility or activity on that site and vice versa. This includes evaluation of site characteristics including: hydro-meteorological conditions, geologic-tectonic, hydro-geological, seismic and engineering-geological conditions; human activity nearby the site and possible induced events on the site, assessment of environmental impact and impact on the population, etc.

Source Term – The amount and the type of radioactive or hazardous material released to the environment following an accident, including the timing of the releases from the starting of the accident.

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G8 NSSG
Nuclear Education and Training – Institutional Capacity-Building

Background

1. Every application of nuclear technology is based on nuclear knowledge. Assuring the smooth and seamless transfer of knowledge from one generation of nuclear experts to the next is a key component of nuclear safety and security infrastructure, with regard to both nuclear power and non-power nuclear applications.

2. International safety standards and security guidance require Governments to ensure that an adequate legal framework is established which requires, inter alia, appropriate training for all personnel engaged in nuclear activities at the regulatory and licensee levels.

3. Human resources are one of the key elements for planning and implementing the various types of nuclear application, setting up adequate and sustainable safety and security national infrastructure

and ensuring the required high level of safety and security within a framework of control and supervision.

4. A significant number of countries worldwide have already expressed their interest in embarking for the first time on nuclear programmes. Not all of these countries can be expected to have adequate experience and expertise in the development of infrastructure and for the education and training of a sufficient number of experts to initiate and sustain a safe and secure civil nuclear power programme.

5. As a result, international and national Education and Training (E&T) activities in the nuclear field are urgently needed in order to ensure the development and maintenance of safe and secure nuclear energy in the countries concerned. Major efforts must be directed towards attracting sufficient numbers of bright and highly motivated students to the field. In addition, E&T is essential to maintain and build capacity at the institutional level, including an adequate and sustainable regulatory framework.

E&T and institutional capacity-building for emerging nuclear energy countries

6. The NSSG Italian presidency is paying special attention to the issue of education and training (E&T), as an essential tool to build capacity at the institutional level, including the establishment of an adequate and sustainable regulatory framework. The focus will be on countries embarking on nuclear power programmes

for the first time (*emerging nuclear energy countries*) and the need to ensure that they are in a position to implement their programmes in compliance with existing international instruments and internationally recognized safety standards and security guidelines.

7. Countries planning to initiate nuclear programmes need to develop the supporting national infrastructure in order to meet safety, security and safeguards requirements as a long-term commitment. Institutional and human infrastructures underpinning this process must be developed as a first step. At an institutional level, infrastructure includes the definition of roles, functions and responsibilities and the establishment of a legal and regulatory framework, ensuring control and supervision, and the implementation of appropriate authorization and licensing processes. Details of national infrastructure, including E&T, are well covered in the IAEA document "Milestones in the Development of a National Infrastructure for Nuclear Power" as well as in the IAEA Safety Standards and Security Guidance.

8. The development of institutional capacity is a government responsibility. E&T is an essential building block in the build-up of capacity at the institutional level, and in the establishment of an adequate and sustainable legal and regulatory framework. Sustainability is a key principle for ensuring that governments take full responsibility, particularly in meeting international safeguards obligations.

9. With respect to institutional capacity-building, E&T needs to focus on the legislative and regulatory

framework, nuclear safety, safeguards, security and physical protection, radiation safety, emergency preparedness and response, and radioactive waste planning. An important aspect of E&T is the comprehensive understanding of roles and responsibilities of all involved parties, e.g. applicants, licensees and regulators. This approach requires vocational training in management, regulatory and decision-making processes, provision for technical support, etc. The promotion of a safety and security culture should be an integral part of a programme aimed at creating institutional capacity-building.

10. Major efforts are required by the countries embarking on nuclear power to develop these infrastructures and capabilities and a number of initiatives are already in place or planned at multilateral and bilateral levels. These initiatives include the efforts underway to increase the number of trained nuclear experts through a variety of education and training initiatives. The sharing of knowledge and experience is essential in order to enable emerging nuclear power countries to make informed policy decisions, and to develop the required institutional capacity-building in relation to safety, safeguards and security.

11. The IAEA plays an essential role in implementing a global nuclear safety and security framework by supporting the establishment or strengthening of national infrastructure, setting up international safety standards and security guidance, and providing peer reviews and services such as the Integrated Regulatory Review Service (IRRS), training and educational programmes, and information networks for sharing

knowledge, experience and best practices. Therefore the IAEA can play a strategic role in supporting E&T programmes and assessing measures to meet these needs in emerging nuclear power countries. The Global Nuclear Safety and Security Network (GNSSN) is also expected to contribute to enhancing capacity-building and safety and security infrastructure through the sharing of knowledge, experience and feedback in nuclear safety and security activities.

12. Vendors have always played an important role in E&T in the development and operation of nuclear power programmes. While this role continues to be valid, what is also evident is the benefit of an increased commitment on their part to supporting the creation of an adequate safety and security infrastructure in the recipient countries. Moreover, the Regulatory Bodies of the country of origin and the recipient country should also be in a position to evaluate the differences in regulatory frameworks and licensing processes and to cooperate with a view to strengthening the recipient country capacity-building, including education and training capabilities.

Proposal of the Italian presidency for E&T and institutional capacity-building for emerging nuclear energy countries

13. The NSSG Italian presidency is proposing that the G8 pay special attention to the issue of education and training, which is also part of the International Initiative on “3S-based Nuclear Energy Infrastructure”, as an essential tool to promote capacity-building at the institutional level in countries embarking on nuclear power, thus contributing to the safe and secure implementation of their nuclear programmes and maintaining high levels of safety and security worldwide.

14. The G8 could contribute to the development of capacity-building at an institutional level and adequate regulatory frameworks by:

    - supporting IAEA efforts and training already underway towards a global nuclear safety and security framework through its programmes and initiatives that will enable countries embarking on nuclear power to make informed policy decisions and develop adequate and sustainable safety and security infrastructure, including education and training of a sufficient number of experts who will be fundamental for their institutional capacity in relation to safety, safeguards and security;

    - promoting effective cooperation among governments, industries, other multilateral groups, and academic communities of emerging and industrialized countries through coordination of ongoing international training in order to strengthen the cooperation on E&T and the sharing of best practices for a safe and secure development of nuclear programmes;

- promoting educational partnerships and networks that will not only strengthen the global safety and security framework, but also streamline structures and resources;

- supporting, on a voluntary basis, initiatives aimed at enhancing nuclear safety and security and ensuring the availability of human resources, e.g. development of nuclear knowledge, and fostering of science, technology and engineering.

15. The NSSG Italian presidency, under the auspices of the Italian government and in close cooperation with the IAEA and the European Commission, is planning an international workshop on E&T and institutional capacity-building focused on safety and security in countries embarking on or expanding nuclear programmes. This seminar will look at current international training programmes for developing countries, assess needs and gaps in resources and attempt to coordinate information and activities and practices already underway.

This Course Booklet has been prepared by ITER-Consult with contributions and review from external experts.

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