WNA Report

International Standardization of Nuclear Reactor Designs

A Proposal by the World Nuclear Association's Working Group on Cooperation in Reactor Design Evaluation and Licensing (CORDEL Group)

World Nuclear Association

Contents

The World Nuclear Association's CORDEL Working Group was established in January 2007 with the aim of promoting the achievement of a worldwide regulatory environment where internationally accepted standardized reactor designs can be widely deployed without major design changes. Its membership consists of industry specialists in reactor licensing, nuclear law and reactor safety engineering, representing reactor vendor companies, utilities, technical support and consulting services and international organizations involved or directly interested in reactor licensing for new nuclear build.

Executive Summary

International standardization of goods and services is a familiar concept. To be feasible, standardization requires that a technology be sufficiently mature to employ designs of well-established quality and safety. This is precisely the case for today's nuclear reactor designs, which represent the culmination of more than 50 years of development.

The concept of standardized reactor designs looks towards a future in which reactors can be built in any country without the necessity of adaptation to specific national regulations. Certainly such standardization will be crucial if nuclear power is to realize its full potential as a major contributor to the clean-energy needs of tomorrow's world. Standardized designs will also contribute to safety in nuclear construction and operations, especially as reactors are deployed in countries that are just beginning to introduce nuclear power.

Achieving reactor design standardization will require the combined efforts of industry, regulators, policymakers, governments and international institutions.

In this paper, the WNA's CORDEL Group proposes a conceptual three-phase programme introducing a mutual acceptance and eventually internationally valid design approvals for standardized reactor designs. But such an evolution towards internationally valid design approvals would necessarily occur in a manner consistent with each country's sovereignty over its own regulatory framework. Each country's regulator would remain responsible for a comprehensive licensing and oversight process, with a streamlined design approval simply being one part of it. No aspect of the CORDEL proposal is meant to imply that any national regulatory process would be subordinated or limited by foreign decisions.

Why is standardization needed?

- **To deliver energy to the world.** Nuclear power provides affordable, reliable and low-carbon electricity, and can make a crucial contribution to the goals of security of supply and global environmental commitments. Once a policy decision has been taken to introduce or expand nuclear energy production within a national or regional energy mix, it follows logically that regulatory, legislative and economic conditions should be established to facilitate fulfillment of this goal. At present, the multiplicity of customized reactor designs and different regulatory approaches and licensing regimes have the effect of increasing cost and uncertainty and thus are far from being optimally conducive to nuclear investment, which depends on the manageability of commercial risk. Standardization that results in transparent and predictable licensing processes and oversight would contribute significantly to a stable investment framework and thereby to a more rapid, efficient and orderly expansion of nuclear power worldwide.
- **To further enhance nuclear safety.** Even without standardized designs, nuclear power has achieved an impressive record of managerial performance and safety. Future standardization offers a remaining major opportunity to enhance this accomplishment still further. Standardized designs will enable both vendors and operators to implement best practices and experience feedback throughout the full plant lifecycles of a worldwide nuclear fleet.

How far does the notion of standardization go?

The concept of standardization does not extend to every detail in a nuclear plant. Rather, it requires sufficient detail to enable:

a) the operator to prepare specifications for the procurement of equipment; and

b) the regulatory body to determine the adequacy of a facility's safety.

Of course, for each individual nuclear power plant a certain degree of adaptation, dictated by site-specific conditions and other local factors, would be necessary.

What can industry do to make standardization possible?

To contribute towards standardization, the nuclear industry should:

- Develop standard reactor designs to a high level of detail.
- Harmonize industry standards and requirements. Efforts should be focused on achieving international convergence of industrial codes and standards applicable to all components that affect safety, as well as of overarching utility requirements.
- For the benefit of operators, expand the use of existing feedback-sharing mechanisms during construction and operation across utilities and national borders.
- Enhance the role of "Owners' Groups" (a cooperation network between a vendor and utilities operating that vendor's design) and by establishing mechanisms for long-term design knowledge management. These actions will facilitate information exchange preserving design knowledge and stimulating design improvements within and across international nuclear power plant fleets.
- With major participation by vendors, develop design-specific training material which could aid utilities in the operation of standard plants and regulators in certification reviews and subsequent operation oversight of standardized facilities.
- Share, with governments and regulators, information and expertise relevant to adapting the regulatory framework toward standardization. Vendors should also share license application documents with other applicants and other countries' regulatory authorities, insofar as the protection of proprietary information allows.

What can governments and regulators do to facilitate standardization?

Governments and regulators should help to create mechanisms specifically designed to foster cooperation on standardization among industry, regulators and law and policy makers. This effort should extend from national to regional and international levels. Harmonization of regulation will provide the essential framework to facilitate international standardization of reactor designs.

The CORDEL proposal is a set of actions - to be taken by industry, governments and regulators - that build on current activities in the direction of achieving the standardization goal. The proposal envisages three phases:

1) **Share design assessment.** Once a design is licensed in one country, the approving regulator should share information with other national regulators, conveying its full experience in the safety assessment of

the design, and receiving regulators should draw upon this experience. Additionally, if several regulators are concurrently reviewing the same design, they could form a collaborative network and discuss their assessment methodology (including criteria) and share their assessment results. This sharing process, which can be undertaken without any change in existing regulatory frameworks, may itself foster tendencies toward harmonization of licensing standards and procedures.

2) **Validate and accept design approval.** Once a design is licensed in certain countries, such design approval could be taken by other countries' authorities after validation as sufficient for licensing there. Although using this simplified validation procedure would heighten efficiency for industry and regulators, it may require some adjustments in existing national regulatory and legislative frameworks.

3) **Issue international design certification**. By international agreement, a procedure could be created whereby a design could be certified by a team of national regulators (from countries with a direct interest in the design). Under the agreement, participating countries would accept this certification. Alternatively, such international certification could be facilitated by a designated international organization. Of course, national regulators would remain responsible for assessing the adaptation of the internationally certified design to local circumstances and for the supervision of construction, commissioning and operation.

These three phrases, representing a steadily increasing level of innovation and international cooperation among regulators and governments, would serve the combined goals of increased safety and regulatory and industrial efficiency.

Expanding regulatory harmonization has to be simultaneously facilitated by alignment of licensing processes and by harmonization of national safety requirements, which currently vary significantly from country to country.

Ongoing regional and international initiatives

This tripartite, stepwise approach provides a useful conceptual framework for the practicalities of bringing about standardization and harmonization. It should also be recognized that there is already some movement in this direction, exemplified by the following:

- Efforts are in hand to identify differences and develop aligned international codes and standards in various domains such as mechanical codes and instrumentation and control (I&C) through such organizations as ASME and AFCEN, and IEEE and IEC .
- Overarching utility requirements for new reactor designs have been developed by EPRI-URD in the US and EUR in Europe.
- A number of multinational regulatory initiatives have been created, the most promising in the area of harmonization being the Multinational Design Evaluation Programme (MDEP). One of its objectives is to establish convergent reference regulatory practices.
- Regional initiatives have been taken by regulators and utilities (such as the Western European Regulators' Association (WENRA) and the European Nuclear Installations Safety Standards (ENISS) initiative in Europe). WENRA has established common reference levels for reactor safety to be implemented in member countries and which will lead to further harmonization.
- The IAEA's Integrated Regulatory Review Service (IRRS) provides reviews of national regulatory systems to identify and spread best practices in licensing and oversight.

- The IAEA also provides a reference point for states seeking to establish a nuclear infrastructure. The IAEA Safety Standards specify safety requirements and guides representing best/good practices, which are increasingly used as reference for review of national safety standards and as a benchmark for harmonization in all countries utilizing nuclear energy for peaceful purposes.

Multinational Design Evaluation Programme (MDEP)

CORDEL proposes that MDEP should be given a more important and formally enhanced role, working closely with the IAEA, as a major driver and forum for governments to coordinate the initiatives outlined above.

- First, MDEP should be backed by an intergovernmental agreement. This would give it more visibility and credibility. The international agreement could be crafted under the auspices of the OECD's Nuclear Energy Agency (OECD-NEA) or the IAEA, or jointly by these two bodies.
- Second, in order to be able to undertake this enhanced role, MDEP should be provided with a dedicated secretariat staffed by specialists with the appropriate levels of experience and expertise.
- Third, MDEP should concentrate on comprehensive design reviews and, as a product of this work, make proposals for harmonization of safety standards to its member states.

If MDEP's role is strengthened as proposed above, it should work in close coordination with the IAEA, with the long-term aim of issuing an international design certification for all new standard designs. This international design certification could then be taken over in individual countries by national regulators, replacing the current system based on bilateral agreements or memoranda of understanding with countries of origin.

Conclusion

The international standardization of reactor designs is essential for achieving increased attractiveness in nuclear investment and for capitalizing on the major opportunity to enhance safety that is necessary if the full potential of nuclear power is to be realized in the decades ahead. Because standardization cannot be achieved by industry alone, the WNA's CORDEL group - representing the coordinated views of the global nuclear industry - strongly recommends a determined joint effort of industry, governments and regulators to achieve the standardization goal.

Only such a joint effort - extending from the national level to cooperation internationally - can produce the changes in the worldwide nuclear regulatory and industry landscape necessary to attain the acceptance and application of common safety standards.

This paper offers the outline of a three-phase approach to achieving the international standardization of reactor designs, which can be certified in efficient, transparent procedures to harmonized worldwide standards of nuclear safety.

1 Introduction: the issue of international standardization

The international standardization of goods and services is a familiar concept. Now that construction of nuclear power plants is back on the agenda in many countries, international standardization is both relevant and necessary, and one of its advantages is its contribution to nuclear safety and regulation. In this paper, the WNA Working Group on Cooperation in Reactor Design Evaluation and Licensing (CORDEL) proposes that international standardization be applied to the design of nuclear power plants worldwide.

The "international standardization of reactor designs" does not imply that there would be only one design in the whole world. Rather, **each vendor who has developed a design would be able to build this design in any country without necessarily having to adapt it to specific national regulations**. We already have experience of this process in other industrial areas, as common industrial standards and regulations have been evolved for export products worldwide.

For standardization to be viable, the technology must have reached a level of maturity that enables quality and safety to be clearly demonstrated. Today's reactor designs, which are the culmination of more than 50 years of development, meet this requirement. We are talking about a small number of Generation III designs, developed by established vendors, building on experience from several decades of reactor operation, and incorporating the most recent high level safety standards.

One of the major objectives of the WNA and its CORDEL Group is to achieve **deployment of internationally standardized reactor designs, which could be certified in efficient, transparent procedures to harmonized safety standards all over the world**. International cooperation and integration will be the means for achieving a change in the worldwide regulatory and industry landscape, setting commonly accepted and applied safety standards and reducing investor and stakeholder risk.

In line with this vision, the future world of standardization would see:

- both vendors and utilities sharing and implementing good practices and experience feedback in the construction and operation of standardized reactor fleets. This will further consolidate the safety and performance benefits to be drawn from standardization.
- national regulators producing harmonized safety standards and a mutually agreed approach to licensing which would be similar in all countries building fleets of nuclear power plants[1].

This would **further benefit the safety of standardized reactors**, both for design and construction and for long term operation, since any further incremental improvements on already high levels of safety would involve the pooling of experience from an ever increasing number of nuclear power plants (NPPs).

It must be stressed that the essential responsibility of each regulatory body for the final approval of safety of the design, site adaptation, quality of construction, and operation supervision will remain. In the long run, however, based on voluntary international agreements, we will see internationally recognized licences issued for standardized reactor designs, somewhat similarly to the process of aircraft licensing used today by the international aeronautic industry (see the special topic, Licensing of aircraft in the international aviation industry, later in this report).

[1] This vision is shared by the IAEA's International Nuclear Safety Group (INSAG), in its report INSAG-21, Strengthening the Global Nuclear Safety Regime (2006), where chapter 6 is dedicated to "Multinational cooperation for the safety review of new nuclear power plant designs".

These goals are ambitious, but there is already **a need to move strongly in this direction in the short and medium term**, in time for the deployment of Generation III reactor designs in considerable numbers, and, in the longer term, for the introduction of future Generation IV designs.

CORDEL notes that these objectives are consistent with the objectives pursued by some multinational initiatives of regulators, especially the Multinational Design Evaluation Programme (MDEP). In this paper, CORDEL will outline the role the nuclear industry can play to achieve its standardization goals; it will also address the facilitating activities needed on the part of regulators and governments. In any case, a strong dovetailing of industry and state efforts will be needed.

2 Why is international standardization needed?

2.1 DELIVERING ENERGY TO THE WORLD

Nuclear power is widely acknowledged to provide affordable, reliable and low-carbon electricity to customers, and thus to be part of the solution for tackling the challenges of energy independence and climate change in a cost efficient way. Policy decisions on whether nuclear energy production should be introduced or enlarged are taken at the state level. However, if a country or a group of countries takes the basic position that nuclear should be a part of the national or regional energy mix, then policy prerequisites necessary for enabling investment in new nuclear power plants have to be provided.

Industry is nowadays much more sensitive to these prerequisites than in past decades, when regulated markets provided a high degree of protection, utilities were often small-scale national entities operating within a state-driven policy, and when technology was frequently indigenous.

Today, in line with the general move to globalization, there is a **new environment for new nuclear build**. A small number of international vendors are marketing their designs across the world, and they are naturally interested in standardization. The same goes for emerging multinational utilities. Crossing boundaries, they are operating, constructing or planning nuclear power plants in different countries, a venture which is made more difficult by diverging national regulatory approaches. In short, industry - comprising both vendors and utilities - is poised to commit much effort to standardization and harmonization. This would be a very important element - besides and in support of others, like implementing a global supply chain and educating young experts - in reaching the general goals outlined above.

However, there is a general perception that the current practice of reactor licensing will not be sufficient to enable delivery of these goals. On the contrary, the **licensing and construction risks** linked to customized and nationally diverging regulatory approaches hamper investment in new nuclear build. What is more, the financial community will support these investments only if the risk is perceived to be manageable.

Given this international scope, standardization based on the international recognition of design approvals, backed by internationally harmonized safety requirements and transparent and predictable national licensing processes, can help achieve **investor certainty**. Nuclear is - with good reason - a very highly regulated industry and nuclear states have highly sophisticated sets of national technical requirements and licensing processes which vary from country to country. This means that standardization cannot be achieved by industry alone but will require significant cooperation with regulators and governments.

Considering the wider picture of the spreading use of nuclear energy for peaceful purposes around the world, standardization of designs and mutual acceptance of design reviews would ensure that **states which desire to introduce nuclear power** can do so in the most efficient and safest way possible. International design approvals based on harmonized requirements would open such countries to the full range of standardized designs available worldwide, encouraging competition and thus improving economics. At the same time safety would be enhanced through making use of the standards established, and by benefiting from the reviews performed, in experienced nuclear countries.

2.2 FURTHER ENHANCING NUCLEAR SAFETY

Construction and operation of standardized plants is a unique opportunity to derive safety benefits, based on the fact that there would be **fleets consisting of many power plants of the same design**. Through such international standardization, positive effects in nuclear safety can be reached.[2]

- The deployment of standardized reactors will offer a much broader basis of **experience feedback** in design and construction compared to the existing system with its many different designs. This will lead to a higher probability of identifying areas for design improvements.
- These **design improvements** could be planned and implemented consistently across the fleet. This approach would keep the standardized plant at the most advanced level of design safety, in accordance with newly gained experience or progress in technology.
- Broader experience feedback would also **fully benefit long term operation** by applying common guidelines and procedures, including for training and human resources policies, and also by enlarging the basis and the ability to detect any deviations or possible improvements and to anticipate any safety issues. This would also apply to decommissioning.
- There might be a perceived risk that in a standardization scenario, a belatedly detected design shortcoming would affect the whole fleet of a particular design. However, this would be more than counteracted by the much higher **probability of early detection of any design flaw**, due to rapid accumulation of experience and due to knowledge exchange, and by preventive provisions at an early stage.

In summary: if well managed by industrial and institutional stakeholders, standardized advanced designs will bring effective additional safety layers for design, construction, operation and decommissioning.

[2] In January 2008, the CORDEL group produced a discussion paper, Benefits Gained through International Harmonization of Nuclear Safety Standards for Reactor Designs, available on the WNA website: http://www.world-nuclear.org/uploadedFiles/org/reference/pdf/ps-cordel.pdf

3 Extent of standardization in plant design

It is important to define the extent of international standardization of reactor designs and to say where the limits of this notion are. Obviously, nuclear power plants of a given design built in various countries will **not be fully identical in every detail**; they will not be mere replicas, to the last detail, of the first-of-a-kind (FOAK) plant. A certain degree of adaptation will be introduced by circumstances such as:

- Characteristics of the site (coastal or riverside, seismic and climatic requirements, industrial environment etc.)
- Design of conventional parts (turbine generator), balance of plant
- Waste treatment and storage facilities
- Certain operational features adapted to the operator's policy (e.g. regarding fuel management, such as the use of MOX, duration of the fuel burn-up cycle, etc.)
- Political requirements or market pressure to "localize" component procurement, which would mean using national codes and standards and possibly adopting some modifications.

Therefore, the notion of **"standardized reactor design" should be restricted to a "core" that, beyond all these issues, would be the same in all projects using this technology**. It would cover

1) the global architecture of the plant, and
2) a level of design which would be sufficient to prepare specifications for equipment procurement and which would enable the regulatory body to decide about the safety of the installation[3].

The aim of CORDEL is that vendors and operators should be able to deploy a standardized design, as defined above, in every country without any changes due to specific national regulatory requirements, thus establishing a strong basis for experience feedback and sharing of good practices. The national regulator would assess and eventually agree to the adaptation of this standard design to the local characteristics and other aspects mentioned above (site, waste treatment, etc.). In addition, the national regulator would assess the arrangements proposed by the future licensee on organizational aspects during construction and operation, including quality control. The standardized design as such, however, would remain unchanged[4].

[3] See, as a reference, the US Nuclear Regulatory Commission (NRC) rule 10 CFR 52.47 which defines the contents of an application for a design certification with, inter alia, the wording: "The information submitted for a design certification must include performance requirements and design information sufficiently detailed to permit the preparation of acceptance and inspection requirements by the NRC, and procurement specifications and construction and installation specifications by an applicant."

[4] After the first one or two plants, there might be some design improvements based on the first construction experience. This aspect will be less important for the "nth plant".

4 Geographic scope

Even if worldwide harmonization is needed, some steps might also be taken on a **regional level**. The most urgent need for harmonization and alignment is apparent in Europe: here, regulators (the Western European Nuclear Regulators' Association - WENRA), utilities (FORATOM's initiative on European Nuclear Installations Safety Standards - ENISS) and the EU (the European Council's 2009 Directive on establishing a Community framework for the nuclear safety of nuclear installations) have already taken the first steps in this direction. This is a good example showing that agreement on common requirements or references can be achieved in reasonable time and with reasonable effort. But it seems that eventually more alignment will also be needed in Asia and the Americas.

However, it would be too simple to presume that there is a logical sequence from regional to worldwide efforts. The regional approach would seem to bring immediate benefits to established industrial or nuclear countries, as in Europe. Here, the benefits of standardization are most apparent for **regulators in countries with small nuclear programmes**, whose resources would be overstrained to make a full assessment of a Generation III design.

When it comes to **emerging nuclear countries**, however, there is an **immediate need for action across continents**. Countries in any part of the world desiring to introduce nuclear power might look, for example, to the US or to European or Asian countries for models and will strive to take over many elements of their systems. For newcomer countries, a certain harmonization might even be necessary in order to enter the market; at least in such cases the benefits of harmonization will take effect immediately. The choice of the "model country system" would, to some extent, depend on the design chosen. Parallel to this, the regulators of vendor countries could be of great assistance to emerging nuclear countries purchasing their country's design. Harmonization and standardization are needed on a regional and on a worldwide scale at the same time.

5 Industry and international standardization

It is obvious that standardization must be conceived and delivered by industry, even if, as will be explained further below, a facilitating regulatory framework is also an important factor.

Many of the possible industry initiatives can be started in advance. Most developments have already begun. In particular, the industry recognizes the urgent need to complete the development of standard reactor designs to a sufficient level of detail (see section 3) prior to commencement of the plant's construction. The industry is also developing new comprehensive approaches to the concept of design knowledge management throughout a plant's life cycle. This effort should foster the work of regulators and governments to enable standardization by adapting the regulatory framework.

What else can the industry do to make standardization possible?

Support governments and regulators in adapting the regulatory framework

Industry should support regulatory initiatives aimed towards standardization and harmonization by **offering its experience and expertise**.

In order to facilitate the sharing of design assessments between regulators, **vendors** should **share existing licence application documents** with applicants and authorities in all relevant licensing processes. Information exchange between regulators should not be hampered, as far as reasonably practicable, by issues of proprietary information.

Harmonize industry standards and requirements

Harmonization of safety requirements is essential for achieving full standardization, as diverging requirements necessarily lead to customization and to country or market-specific solutions. Because basic safety requirements are contained in high-level regulatory documents and, at least partially, in legal provisions, their international harmonization would require an action by regulators and governments (explained in sections 6 and 7). However, many detailed technical solutions in nuclear power plants are defined by industry standards.

Many countries have developed their own industrial codes and standards for products and services and these are only applicable nationally or within a group of other countries which accept them. This can lead to limitations in access to international markets for many products and services which could otherwise be more widely available, which would significantly enlarge the offer and improve competition in the international supply chain of scarce equipment and components.

Therefore, it is only logical that industry should work together towards wider **internationally accepted codes and standards** in various domains, such as mechanical codes or instrumentation and control (I&C). Much cooperation between the organizations producing industrial standards is already taking place. For example, studies have been launched to compare mechanical codes of the ASME[5] and AFCEN's RCC-M[6]. Similarly, agreements have been reached between the IEEE[7] and IEC[8] to develop common industrial electrical standards for the nuclear industry. Increased alignment of codes and standards would also help to enable regulators to accept foreign codes and standards provided they represent good modern international practices in compliance with national safety regulations.

Furthermore, industry has already invested much effort in activities to set common standards in **defining overarching utility requirements** for new reactor designs (Utility Requirements Document (URD) in the US, produced by the Electric Power Research Institute (EPRI), and European Utility Requirements (EUR) in Europe). These sets of criteria should give regulators confidence in industry's commitment to the deployment of standardized designs. The "certifications" which are the outcome of an industry review of specific designs could, to a certain extent, be a predecessor to a multinational design acceptance[9].

Improve safety through streamlining of experience feedback

International standardization offers a **unique opportunity to make optimal use of best practice and feedback sharing mechanisms** and to maximise their contribution to nuclear safety. A great deal is already being done to share operating experience and to jointly derive measures for safety improvement, for example under the auspices of the World Association of Nuclear Operators (WANO). Nevertheless, the industry should take the opportunity presented by standardization and strive to improve these mechanisms still further.

Operators should introduce or improve operating experience sharing and evaluation programmes, both within multinational companies and between different companies operating standardized reactors. As mentioned in the introduction, we are witnessing the emergence of multinational utilities, managing a fleet of one or two standardized designs across a range of countries. These utilities would have a responsibility to make a first effort to achieve, in collaboration with vendors, the implementation of standardized designs and to establish a mechanism for optimized experience feedback and best practice sharing in their own organization. This concept could then be spread across utilities to install a global network for each design.

The same would apply to construction experience feedback. This feedback could be distributed and analysed on two tracks: one would comprise general issues and be applicable to all designs; the other would be design-specific and would be coordinated by the vendor offering the respective design.

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[5] ASME - American Society of Mechanical Engineers
[6] AFCEN's RCC-M - Association Française pour les règles de Conception, de construction et de surveillance en exploitation des matériels des Chaudières Electro Nucléaires (AFCEN): Règles de conception et de construction des matériels mécaniques des îlots nucléaires, France
[7] IEEE - Institute of Electrical and Electronics Engineers, US
[8] IEC - International Electrotechnical Commission
[9] In July 2009, Areva's EPR was the most recent reactor design so far to be certified by the EUR.

Enhanced role of vendors

Generally, vendors should assume a more substantial role in supporting operators in fulfilling their responsibility for safety. The fundamental principle of the operator's prime responsibility for safety[10] would obviously remain, and the operator would remain solely liable for third party damages; nevertheless, vendors could be involved to a greater extent in keeping and improving safety of a design during operation. One basic means to achieve this is to **strengthen the role of "Owners' Groups"**. These are groups which unite the vendor of a given design and the utilities operating this design. They could play a decisive role in spreading design improvements across all plants of the same design in a coordinated manner.

Standardization would also create a **unique opportunity to establish mechanisms for reliable long-term knowledge maintenance** for any design. Full knowledge of the design needs to be maintained across the whole life cycle of a nuclear power plant, especially for the sixty years that new nuclear power plants will likely be in operation. In today's concept, this knowledge would be gathered and managed by an entity within operator's organization: the design authority[11]. However, it is probably not realistic to demand that every operator in the world, even a one plant operator, be able to establish and support a full-size design authority in its organizational structure; nor would it seem reasonable to expect full engineering knowledge of the same design to be fully maintained separately by several different operators.

Standardization will offer the possibility of overcoming this difficulty[12]. Nuclear new build worldwide will likely consist of a handful of fleets, each of the same standardized design. Vendors, in close collaboration with utilities as "intelligent customers", will play an important role in the exchange of information and operation experience within "their" fleets and across the fleets worldwide. They will help maintain design knowledge and play an enhanced role in initiating design improvements which might result from this experience feedback. This implies again a strengthened role for the Owners' Groups. For this close cooperation of vendors and operators, the aviation industry might be an example for an overall concept to apply (see the special topic, Licensing of aircraft in the international aviation industry, later in this report).

Vendors might also be tasked with development and maintenance of **design-specific training materials** required by both the utilities operating their standardized design and the regulators tasked with oversight and monitoring of the operation of the design. This will support regulators in their decision to take advantage of a full certification review in another country.

[10] See IAEA Safety Fundamentals, Principle 1: Responsibility for safety: "The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks". See also Article 9 of the Convention on Nuclear Safety: "Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence ...".
[11] The concept of design authority is explained in INSAG-19, Maintaining the Design Integrity of Nuclear Installations throughout their Operating Life, 2003.
[12] This was discussed comprehensively in: John Waddington, "Challenges to the Regulation of Generation III Reactors and the Nuclear Renaissance", Nuclear Inter Jura Congress, October 2009, Toronto (in press).

6 A stepwise integrated approach to a regulatory framework enabling standardization

Standardization as such must be delivered by the industry, but industry needs to be enabled to accomplish this objective within adapted national and international regulatory frameworks for nuclear power.

The fact that industry action needs a context, shaped by government action, regulation and legislation, that removes obstacles and enables it to perform its duties, is quite common, and applies particularly to the nuclear industry. This has been noted by the OECD-NEA: "Strong and consistent government support is an essential prerequisite for initiating or expanding any nuclear programme"[13]. If an energy policy calls for nuclear power to be part of the energy mix, then government needs to provide the regulatory infrastructure to allow for industry to act on this. Elements which are more and more universally recognized are **an efficient and effective licensing process** and a reliable strategy for management of nuclear waste and spent fuel. In the same approach, the benefits delivered by international standardization of reactor designs should be a matter of policy and should be made possible by facilitative actions and, if necessary, by adapting regulatory processes or national legislation and new international agreements.

Nuclear regulators should also be interested in international standardization as it strengthens nuclear safety (see section 2.2). Besides, a mutual acceptance of standardized designs would **relieve the strain on regulators' resources**. A national regulator, while maintaining its own responsibility, could benefit from the work done by its peers and would not have to reassess a design all over again.

Therefore, CORDEL, fully acknowledging that standardization needs to be delivered by industry and that industry has to take action to support regulatory developments and to bring to fruition the full scope of safety benefits of standardization, proposes a set of actions for governments and regulators in order to enable industry to fulfil this commitment.

In short, the concept of internationally standardized reactor designs across many countries can materialize through streamlining and step-by-step alignment of the design review and approval processes of these countries.

Scope of harmonization and mutual acceptance

It has to be stressed that design review and approval **form only one part of the overall licensing process for new nuclear power plants** (Figure 1). In every country, prior to licensing there is a need for a policy decision to be taken on a nuclear new build programme and on the feasibility of a particular nuclear power plant project. The actual nuclear licensing process covers, besides the reactor design, the assessments of the site and the applicant/licensee. Finally, construction and operation have to be authorized and supervised by the regulator. All these steps, except for the design review, are not affected by the proposals in this paper and would be taken in fully comprehensive national procedures. **Therefore, no part of the CORDEL proposal should be seen as aiming at "importing" the licensing decision for a nuclear power plant from a foreign country.**

[13] OECD-NEA Report: The Financing of Nuclear Power Plants, 2009.

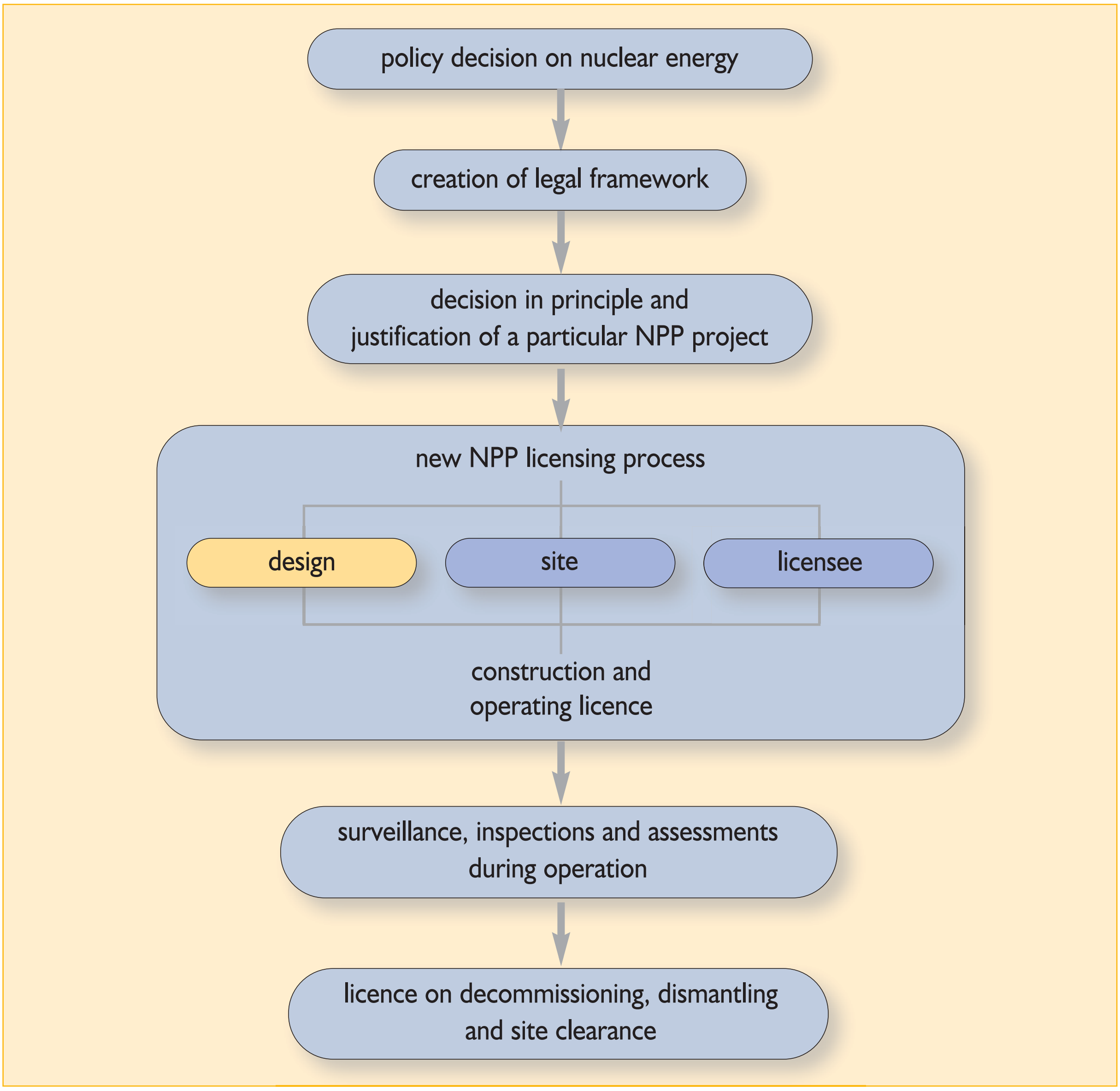

Figure 1: Design Approval as part of a comprehensive national regulatory process

Stepwise integrated approach

To reach the aim of installing a regulatory framework enabling industry to deliver standardization, CORDEL proposes a **stepwise integrated approach**.

The approach is **stepwise**, as there are three phases proposed in order to give a structure to the road to full standardization and harmonization. Some headway, in a first phase, could be achieved by all players within existing policy frameworks. For the second and third phase, some adaptations and innovations in industry policy, regulations, legislation and international cooperation may need to be introduced to facilitate the process.

The approach is **integrated** because the contributions of all stakeholders need to interlock: industry must bring to bear all the benefits of standardization on nuclear safety and performance; governments and regulators must provide a framework to make this possible; international institutions and other stakeholders must provide their contribution and acknowledge the results.

The three phases

The three phases are defined by the extent to which an approval issued for a certain reactor design can achieve multinational recognition.

- Phase one: **Share design assessment.** If a design has already been licensed in one country by a regulator, based on full experience in the safety assessment of the design, the regulators of other countries subsequently entering into design review should make full use, when following their own comprehensive licensing process, of the design assessment reviews - entirely or in parts - already performed in the first country. This could be achieved by regulators within the existing framework. Alternatively, if several regulators are concurrently reviewing a design, they could form a collaborative network and discuss their assessment methodology (including criteria) and share their assessment results. The outcome of this interaction should be reflected in design approvals that are more or less identical in content, though issued by each separate regulator. This should lead to practically the same design being employed.
- Phase two: **Validate and accept design approval.** If a design is already licensed in one country and is later proposed for other countries, the existing approval could be taken over by the other countries following a simplified validation procedure. This may require some adjustments in regulations and legislation.
- Phase three: **Issue international design certification.** For a given design, a form of "international design certification" could be issued by a team of regulators or, in a more distant perspective, through an international organisation. This would obviously presuppose the existence of an international framework to which national regulations are aligned. This international design certification would be valid in all countries which choose to participate through voluntary agreements.

In order to facilitate the implementation of the three phases, a parallel, ongoing **alignment of licensing processes** needs to be achieved, at least **in the longer term**. These processes are different from country to country. A convergence of these processes would facilitate the mutual acceptance of foreign design reviews and design approvals.

Finally, a full team approach in design evaluation and approval, an acceptance of foreign design approvals/licences or a multinational design certification/licence will only be possible if facilitated by **harmonized national safety requirements**. The licence basically is the statement by the competent authority that the project complies with the (safety) requirements imposed on it by its national law and regulations. Alignment of national safety requirements culminating in the establishment of a single harmonized international regime of safety requirements is a long-term process but, just as the other workstreams, it should be started as soon as possible and fostered step by step.

These three issues - multinational recognition of design approvals, alignment of licensing processes, and harmonization of safety requirements - need to be tackled simultaneously in the framework of the integrated stepwise approach.

Overview: Integrated stepwise approach to standardization

<table>
<tr><th></th><th>Multinational cooperation in design review & approval</th><th>Licensing processes</th><th>Safety requirements</th><th>Industry contribution</th></tr>
<tr><td>Phase 1: Share design assessment</td><td>Regulators to make use of design assessment performed by a foreign regulator to inform their own licensing decision.
In case of concurrent review of a design, regulators to share assessment criteria and results to be reflected in more or less identical design approvals issued by the regulators separately.
FOAK regulators to provide for exchange of assessment results with their peers.</td><td>Licensing processes to be aligned to best practice models as far as possible within the existing legal framework.
FOAK regulators to issue a separate design certification, thus making the design review more accessible.
Format and content of licensing documents to be aligned as much as possible.</td><td>Regulators to foster comparison and mutual understanding of high level national safety goals.
Deviations of national requirements from international practice (which might become apparent precisely by design review activities) to be analyzed and progressively reduced.</td><td rowspan="3">• Vendors to promote sharing of licence application documentation.
• Industry to make comparative studies and encourage convergence of codes and standards.
• Utilities to enhance the use of common Utility’ Requirements.
• Enhanced construction and operational experience feedback mechanisms to be installed.
• Role of Owners’ Groups to be strengthened.
• Industry to develop mechanisms to maintain and share design knowledge (“design authority”) and the concept of “design ownership”.
• Vendors to establish design-specific training materials.</td></tr>
<tr><td>Phase 2: Validate & accept design approval</td><td>Regulators to mutually accept a foreign design certification in a facilitated procedure (“validation”).</td><td>Adaptation in licensing processes, with potential changes in legislation, to allow for this.
Format of documentation to be more fully aligned in order to make a design acceptance issued in one country fit into the licensing sequence of another country.</td><td>Stronger convergence of national safety requirements. Resolution of major controversial issues.</td></tr>
<tr><td>Phase 3: Issue international design certification</td><td>Internationally valid design certifications to be issued by team of regulators or through an international organisation.
Governments to adapt legislation and conclude international agreements to allow for this.</td><td>Common structure of all national licensing processes to support an international validity of design certifications.</td><td>Harmonization of safety requirements to a level of detail sufficient to describe the safety features of a standardized design.</td></tr>
</table>

PHASE 1: SHARE DESIGN ASSESSMENT

This phase could start immediately - in fact, some elements are already being tackled, to a varying extent, by initiatives such as MDEP.

a) Design review and approval. In this phase, regulators who have received a licence application would **make use of an assessment of the same design already performed in other countries**. When several regulators are confronted with reviews of the same design more or less at the same time, they would, possibly in a joint review team, share their evaluation methodology and criteria and assessment results. As a result, the design approval issued by each separate regulator would substantively follow the jointly established model - even if its outer shape would be modelled to national legal requirements. The important point is that the conclusions of all regulators involved would be the same, leading to an acceptance of an (as far as possible) identical standard design based on the same safety principles.

Of course, in the existing framework, every regulator would need to fully assess whether the proposed design matches the safety requirements valid in their own country. For demonstration of this required level of safety, however, the regulators could coordinate their work, or they could make use of the assessment work already done by their peers, for example by re-using calculation results or modelling of event sequences. The assessment elements provided by other regulators could be taken over as if they were the result of the work of the safety expertise (in-house or contracted) which the regulator would use anyway. The review performed by a regulator should be informed by what the fellow regulator has done or is doing. In any case, **the regulator will take the final decision whether this demonstration of compliance is sufficient to warrant the issuance of a licence**.

Within the framework of the design-specific working groups, MDEP regulators are already sharing information and experience on design reviews and construction oversight. At the global level, such sharing makes safety assessments more robust and increases the safety level of the analysed designs.

When participating in a joint assessment or when looking at a design assessment performed by a peer, a regulator could also **make use of the general assessments which have been performed by the industry**. As pointed out in section 5, industry has already done a great deal to set common standards in defining overarching utility requirements for new reactor designs (EPRI-URD in the US, EUR in Europe), and in assessing how far a given design complies with these standards. These reviews would facilitate the work of regulators in different countries and could, to a certain extent, even be a predecessor to a multinational design acceptance.

In case of a FOAK licensing process, the regulator would take care that the assessments performed by his staff or any contractors are structured in a way to allow their subsequent use by others. The regulator should give his peers access to these assessments. If possible, he would arrange for staff of interested fellow regulators to be integrated into the assessment team in order to familiarize themselves with the design.

Special topic: Multinational Design Evaluation Programme

Many of the suggestions presented here for Phase 1 are on the agenda of the Multinational Design Evaluation Programme (MDEP)[14]. MDEP is an initiative of the regulators of 10 new build countries with the aim of leveraging resources and of identifying common regulatory practices. Members are the national regulators of Canada, China, Finland, France, Japan, South Korea, Russia, South Africa, the UK and the US, plus the IAEA. The NEA in Paris provides the Technical Secretariat. Its Pilot Project phase, started in 2006, was completed in 2008, since when MDEP has been in full working mode. This joint effort allows regulators to:

- leverage the technical evaluations completed by each of the participating regulators,
- leverage the resources and knowledge of the national regulatory authorities,
- develop consistency between regulators and/or to understand differences,
- develop joint assessment on specific subjects.

The work in MDEP is done by different working groups. There are two design-specific working groups (for the EPR and for the AP1000) and three issue-specific working groups (Digital I&C Standards; Codes and Standards; and Vendor Inspection Cooperation).

MDEP is prepared to create new design-specific working groups provided that more than two MDEP country members are involved in a review of a given design. These design-specific working groups are, in scope and depth of collaboration, not yet a full joint design review as proposed above, but they are definitely a step in the right direction.

CORDEL strongly welcomes this multinational initiative and offers industry support in every aspect which could be considered to be useful. It is to be hoped that the MDEP process will in the short term facilitate the design reviews currently undertaken by MDEP member regulators and in the mid-term lead to some alignment in regulatory practices.

In section 7, this paper will examine ways of enhancing this process still further.

b) Licensing processes: Currently licensing processes in different countries vary considerably. Some countries carry out licensing only for specific projects. In the licensing process, the three main elements of any nuclear power plant project - design, site, and operator/applicant - are assessed jointly in the frame of the review performed for the project-based application. Some countries use a one-step licensing process; others use a sequential approach with a licence needed for different steps of the process (site, construction, commissioning, and operation).

Other countries have introduced a separate pre-licensing step where a design is assessed and approved independent of a particular project and a particular site. The result of this pre-licensing may take different shapes: it can be a legally binding “design certificate” with a defined scope (in the US) or a rather less binding and less comprehensive “design acceptance confirmation” (in the UK). This result would be referenced in the licence application for a specific project.

Generally, the differences complicate the process of mutual acceptance of assessments, since different styles of licence require different levels of assessment[15].

As to the wording used in the present document, the general term used for the “clearance” of a design by the competent authority - be it in a stand-alone document or in the framework of a project-based licence application - is “**design approval**”. A **design certification** would be one specific type of design approval, namely a stand-alone licence for a design, independent of a particular site or operator, which is to some extent legally binding on the issuing authority.

[14] http://www.nea.fr/mdep

[15] IAEA TECDOC 936 defines five stages in design development with potential links to different licensing phases. Although the "Basic Design" stage (stage 3) is identified as being sufficient for design certification, later stages (stages 4 and 5) would be required for a construction and operating licence. A single licence, like the UK Nuclear Site Licence, would require information which would be closer to stage 5.

The differences in licensing processes will certainly not be overcome in the short term. However, it would be helpful if the **first assessment of a design could form a self-contained process** and result in a stand-alone document, not involving site- and operator-specific elements; this would facilitate the task of other regulators later confronted with applications featuring the same design in other countries.[16] This **design certification** should be based on a **comprehensive in-depth review of the design**.

Special topic: FOAK

The regulatory review and licensing of a first-of-a-kind (FOAK) design is a groundbreaking step and creates a model which influences the subsequent licensing processes in other countries. Experienced regulators in countries with a well-established nuclear programme who are confronted with a FOAK application should acknowledge a responsibility towards their peers in smaller countries or in newcomer countries who would have difficulties to perform a full-scope design review all by themselves.

Therefore, the FOAK regulator should

- make a full in-depth assessment of the design
- issue a stand-alone design certification
- give other regulators the opportunity to collaborate on/contribute to assessment topics
- integrate staff from other regulators into the assessment team.

Another issue is the **format and content of licensing documents** supporting the demonstration that the design is safe enough. Here, there are substantial differences, for example, between the Technical Guidelines for next generation NPPs issued by German and French regulators, the Design Control Document which is at the core of the US design certification process, and the documents needed to support the UK Generic Design Assessment (Pre-Construction Safety Report). If one document is to be used at all in another country, it has to be thoroughly "translated" (not only linguistically) to the other system. Concerning the actual licensing process, the scope of the Preliminary Safety Analysis Report (SAR) (preceding construction) and the Final SAR (preceding operation) differs in different countries. Here, some quick convergence should be reached.

c) Safety requirements: As set forth in the introduction to this section, **harmonization of safety requirements** is an important point for enabling regulators to accept a design assessment performed by another regulator or to share assessment criteria and assessment results. First experience with new build applications has shown that a design review is a very good opportunity to compare different regulations and to test whether national "deviations" from the international mainstream approach are really justified or to what extent they are rather the result of historical developments.

There is already a great degree of alignment on a high level[17]. One reason for this is the development of **safety standards of the International Atomic Energy Agency (IAEA)**, which have evolved from a set of minimum requirements, embodying the "lowest common denominator" and in practice addressed to developing nuclear states, to a high benchmark used also by experienced nuclear countries. Even if the Agency's safety standards are not binding on IAEA Member States, there is an ever increasing international consensus that national regulations should be based on, or at least not contradict, these standards, and it has become a common exercise to benchmark national requirements to the IAEA standards.

[16] There seems to be a growing tendency to implement such stand-alone design approvals in national legislation or regulatory practice. The US has taken the lead with design certification introduced in the 1990s. The UK has initiated, based on the January 2008 White Paper on Nuclear Energy, the Generic Design Assessment (GDA) procedure. In France, a 2007 government Decree on nuclear installations (no 2007-1557, 2 November 2007) offers the possibility for an applicant, before starting the actual licensing procedure, to ask the regulator ASN (Autorité de Sûreté Nucléaire) for a statement (avis) on the safety of a design.

[17] This is also stated in INSAG 21, Strengthening the Global Nuclear Safety Regime, 2006, para. 53: "The general safety goals and requirements for nuclear power plants in different countries, and the design solutions to meet them, have currently reached a state of reasonable harmony".

International peer reviews among regulators, like those in the framework of the Convention on Nuclear Safety, are another important factor in aligning views and approaches to nuclear regulation. Altogether, fundamental safety goals are essentially equivalent in all nuclear countries, and the same fundamental engineering and safety principles, like defence-in-depth, apply everywhere. What differs, however, is the demonstration of safety and the details of implementation, the assumptions for the design basis, and other elements as defined by national guidance and regulations.

Regulators' initiatives focused on alignment and harmonization of national safety requirements can address this problem. While the MDEP does not intend to develop new harmonized requirements as such, one of its declared objectives is to achieve a convergence of regulatory practices by establishing Reference Regulatory Practices. These are to be shared with the IAEA for consideration in the IAEA safety standards development programme. As CORDEL understands it, a comparison of high-level safety goals is being undertaken by the WGRNR[18] group of the OECD's Nuclear Energy Agency (OECD-NEA). Finally, on a regional level, the Western European Nuclear Regulators' Association (WENRA) has established common reference levels for reactor safety which are to be implemented in each member country and will lead to further harmonization.

Special topic: WENRA

The Western European Nuclear Regulators Association (WENRA) could be taken as a best practice example for alignment of safety requirements. In a process starting in 2003[19], WENRA has established reference levels in order to define a common high level of safety for existing nuclear power plants. The methodology of defining and implementing these reference levels is very stringent, at the same time respecting the members' sovereignty and benefiting from industry input. The participating regulators benchmarked themselves - their regulations and their practices - against the reference levels. Discussions were held with stakeholders, particularly industry, in order to improve the reference levels. Finally, the regulators committed to implement any necessary changes in their regulations by 2010. Even if these reference levels are not, strictly speaking, a set of safety requirements, in practice the involved regulators take a common approach in modelling their national regulations on these reference levels. They are poised to align safety regulations in the participating states. Therefore, WENRA could be a model for international voluntary cooperation of regulators aiming for a greater harmonization of safety requirements in order to achieve a consistent high level of safety worldwide.

Altogether, there is a general recognition that a **proper comparison and mutual understanding of national safety goals** would lead to the conclusion that a large proportion of any design assessment performed in one country would lead to compliance also with the main principles valid in other countries. Of course, there are still many differences in the details. **These differences would have to be analysed and progressively reduced.** As those details are mainly contained not in laws and decrees, but rather in regulations issued by the national regulators, there would be room for regulators to go a long way in this direction. In the long run, there will have to be changes in legislation and a new set of international agreements to facilitate this process. This is addressed in Phases 2 and 3 explained below.

A first alignment in Phase 1 could either be reached by regulators checking their own set of regulations and identifying discrepancies which could be adapted to an international consensus, or by regulators accepting foreign requirements on a case-by-case basis, provided they are in line with their own high-level safety goals.

[18] Working Group on the Regulation of New Reactors. This Working Group reports to the Committee on Nuclear Regulatory Activities (CNRA) of OECD-NEA.
[19] A pilot project had already started in 1999.

Special topic: New nuclear countries

International standardization of reactor designs provides new nuclear countries with the beneficial opportunity of developing a state of the art nuclear infrastructure and regulatory regime. Such countries would have the chance to model from the very beginning their own national set of safety requirements on internationally acknowledged standards (like the IAEA safety standards) and thus make them basically applicable to any of the available Generation III designs. Alternatively, newcomer countries could forgo the development of their own national standards and instead **accept, in the licensing process, the regulations of the countries of origin** of the proposed design. This implies accepting, for the demonstration of safety, these countries' regulations.

Both approaches, either adopting international safety standards or accepting the use of safety regulations of acknowledged vendor countries, would benefit the effect of a stand-alone design certification issued by the country of origin, with the participation of teams of newcomer countries' regulators. Both approaches might be used, as an example, for SMRs (small and medium-sized reactors) destined for use in developing countries (or countries with a smaller electrical grid capacity). The issuing of such de facto "export certifications" could provide the occasion to promote bilateral relationships between experienced and newcomer countries' regulators.

Vendors will have the incentive to develop a range of standard designs of different capacities without being restricted by their domestic markets. On the regulatory side, such "models" of infrastructure programmes could be developed and administered by experienced countries through international organizations like the IAEA. Thus, the best practice of experienced countries will form the reference scenario for newcomer countries, enabling them to capitalize on the technological and regulatory work done in countries of origin.

Compared to an acceptance of foreign regulations, an acceptance of foreign **codes and standards** is generally more manageable, as these are not set by states as an expression of their regulatory sovereignty, but by the industry itself. In the past, some countries which did not have their own sets of codes and standards accepted the standards of countries of origin of the reactor designs which they were deploying[20]. But of course such mutual acceptance of codes and standards could also work for industrial countries which already have their own codes and standards, but do not make them obligatory by reference to them in their regulations.[21]

As cooperation between regulators and exchange of assessment results proceeds, it would become more straightforward for regulators to recognize the merits of various regulatory approaches. **Unique national requirements leading to changes to a design would have to be justified with good reasons** in the international circle of regulators, particularly if the introduction of differences in the initially standardized design would seem to jeopardize part of the benefit which could be drawn in the future from experience feedback sharing. This would constitute a very high incentive to adhere to reasonably established requirements and to avoid "goldplating".

PHASE 2: VALIDATE AND ACCEPT DESIGN APPROVALS

a) Design review and approval: In this phase, mutual acceptance would not be confined to the design assessment. Instead, regulators would, in a facilitated procedure, take over the final result of the design assessment, namely the **design acceptance** (which would preferably, as explained above, be embodied in a formal **design certification**).

[20] Examples from the past are Spain and Switzerland, which have allowed for the relevant original standards (US's ASME and Germany's KTA) to be used as they built nuclear power plants of the US and German designs.

[21] Recently, UK regulator the Nuclear Installations Inspectorate (NII) has clearly stated it will accept foreign codes and standards. (New nuclear power stations - Generic Design Assessment - Safety assessment in an international context. March 2009, para. 25, available at http://www.hse.gov.uk/newreactors/international.htm)

This is not meant to be a simple taking over of a design approval ("rubber-stamping")[22]. Every regulator is bound by law to decide whether the project described in the application complies with national safety requirements. National regulations also have to ensure public input and participation in the process and that public concerns are adequately addressed in the licensing process. The regulator cannot divest itself of these duties. Because of this, there would need to be a system making sure that the acceptance of another regulator's design approval is based on the national regulator's full competence and knowledge. This is to be assured by the **concept of validation** as proposed here.

In order to take into account these prerequisites, the following steps for the **validation**, by an "accepting regulator", of a design approval issued by a "lead regulator," are suggested:

- A validation can only be based on an international framework.
- It would require that the "accepting" regulator has reviewed the standards and processes of the regulator who has issued the design approval, and has gained the conviction that he is experienced and trustworthy.
- The process of validation would suppose a close collaboration and an involvement of the "accepting" regulator in the review process, so that he becomes fully knowledgeable, which is indispensable for any national regulator.
- The process, based on these steps, would result in the "accepting" regulator taking over the original design approval. The focus of the "accepting" regulator's own assessment would be on reviewing the design against those of his national requirements which differ from those of the country of origin (the so-called "national delta").

These steps are not a CORDEL invention. They already exist in the aviation sector and apply to the licensing of commercial aircraft.

Special topic: Licensing of aircraft in the international aviation industry

In civil aviation, a Type Certificate is awarded to the designer/manufacturer of the design by the competent national or regional aviation authority first of the country of origin and then of every country where an aircraft of this design is to be registered. The Type Certificate can be roughly compared to the reactor design certification, conceptualized in this paper. A carefully balanced international system exists to facilitate and streamline the certification processes:

• The Chicago Convention on International Civil Aviation, linked to a specialized UN agency, the International Civil Aviation Organization (ICAO), provides a **general international framework** for regulatory cooperation and an envelope of minimum safety standards.

• Authorities collaborate in type certification on the basis of **bilateral agreements**. Through conducting an evaluation of each other, participating authorities conclude that the other party is a **trustworthy and experienced regulator with well-established procedures**.

• When performing its design review, the aviation authority of the country of origin involves experts from the aviation authorities of the major other countries **in the review team**. This results in literally simultaneous production of Type Certificates in all countries involved. Authorities which do their review later will also closely cooperate with the authority of the country of origin.

• When performing their design reviews, the authorities of the other countries will not re-do the assessment done by the authority of the country of origin. Instead, they will concentrate on validating the Certificate **against the "national delta"**.

Of course, it is necessary to acknowledge the considerable differences between aircraft and nuclear reactors. One of the main differences surely is the general impact and political scope of a reactor licence. However, the main ideas of this approach, which governments, regulators and the aviation industry have successfully developed in a process taking a number of decades, should also be considered for benchmarking in nuclear.

[22] A simple taking over would not be possible for legal reasons under existing legislation; this is emphasized in the UK NII document on safety assessment in an international context, as quoted in the previous footnote, paras 6 to 16.

Another example, which is more closely related to reactor licensing, is the field of transport of nuclear materials. Here, according to the relevant IAEA Requirements, the licence for a transport cask ("package") issued in one country can be validated and taken over by the regulators of other countries[23].

Recently, there is even an example of this principle being employed for nuclear reactors. Italy's recent Act on Energy Companies, A.S. 1195, states as follows (Art. 14, 2 i):

> *[Government is empowered to issue] a provision that licences relating to technical requirements and specifications for reactor designs which have been licensed in the past 10 years by the competent authorities in member states of OECD-NEA, or in states having bilateral agreements with Italy on technical and industrial cooperation in the nuclear sector,* ***will be considered to be valid in Italy after approval by the Nuclear Safety Agency*** *[emphasis added].*

The wording of the Act makes quite clear that design licensing decisions taken in other countries can be valid as such in Italy, provided the national regulator gives its approval. So, this can be seen as a **first example of a "validation" procedure for foreign design approvals**, introduced in the legislation of a country which has adopted a policy of reviving nuclear, knowing that this will not be possible without making full use of the international aspects of new nuclear build.

The objection to a simplified validation procedure has been raised that the **regulator must himself acquire sufficient knowledge of the design**. Of course, at first glance a full-scope design review is the best way to achieve this, and this reason is sometimes put forward to explain that a regulator cannot do without such a design review. However, it would seem that any regulator would have enough opportunity for familiarizing himself with a design by cooperating with a fellow regulator who is assessing the design and, when he himself is dealing with a licence application, by preparing and issuing the construction and the operating licence, and with the supervision of those activities. There would be **no need to re-do a design assessment just for the purpose of familiarization**.

To facilitate this process, the CORDEL group recommends that the **IAEA drafts a guideline regarding the content of such a "safety validation" process** by which a regulatory body could endorse and take over such a pre-existing licence approved by another regulator after an in depth assessment. This initiative could be encouraged in order to give a formal recognition of this "ownership" process by another regulator.

Special topic: "Ownership" of a design certification, control of design changes and examples from aviation industry

A design certification is, to some extent, a "living" document - in any case, the job is not over once it is issued. In a framework of international cooperation and mutual acceptance, this fact causes some problems which need to be addressed and overcome. For example: if a design flaw is detected, who is responsible for overseeing the re-design? Is it the regulator of the country where the incident has occurred, or is it the regulator of the vendor country? After a design improvement, which design has the status of "certified design" - the original one or the improved one? Another question would be how it can be made certain that a design improvement is extended to all plants of this design across the world.

Problems of this kind can best be addressed by creating a network of all authorities concerned; an approach in which the design certification issued by a "lead regulator" is simply taken over by others would not seem adequate for this. An example could again be civil aviation, where type certificates are jointly kept up-to-date, and design improvements are implemented in all aircraft of the particular type concerned, by way of a close collaboration of regulators, international authorities, vendors and operators (airlines).

[23] See IAEA Requirement TS-R-1, Regulations for the Safe Transport of Radioactive Material, 2009 edition, no. 834 "validation of certificates".

The following mechanisms can, arguably, be borrowed by the nuclear industry to address the evolving concept of a design over its lifetime:

• As part of the type certification, the designer has to draw up a **maintenance programme** to support continuous airworthiness of the whole fleet.

• The designer organization establishes a **reporting system** with all operators.

• If during operation a design problem that can compromise aircraft safety is discovered, the regulator must issue an **Airworthiness Directive** (additional design maintenance actions mandatory to all aircraft of this type) to the holder of the Type Certificate (the designer). This action will affect all owners globally.

• The designer issues **Service Bulletins** to advise on design changes which may lead to increased performance or reduced maintenance cost and time.

Even when production of this aircraft type has ceased, the designer keeps the Type Certificate valid by continuously following current rules and regulations, by collaborating with authorities on issuing airworthiness directives and service bulletins, as well as providing spares and technical support to the owners and operators of this aircraft type.

The CORDEL group, as the next step, is dedicated to further investigating various mechanisms and their applicability to the nuclear industry.

b) Licensing processes: Obviously, for Phase 2 there would have to be some alignment in the way of implementing the demonstration of safety within the licensing processes so that a design acceptance document issued in one country would fit into the licensing sequence of another country. The same applies to the supporting documents mentioned in Phase 1 (Design Control Document, Pre-Construction Safety Report, etc.), the format and contents of which need to be more or less fully aligned in this phase.

Moreover, a certain **flexibility in licensing** should be introduced. **One-step licensing** (when construction permit and operating licence are combined in one licence authorizing construction and conditional operation of a plant) accompanied by the stand-alone design certification process, such as adopted by the US, can be used for the assessment of a FOAK standard design. The one-step process gives comfort to an applicant at the time he starts construction that he will be allowed to operate the plant if he complies with clearly defined acceptance criteria.

Once a standard design has been certified in one country and certain confidence in its safety can be gained from the FOAK plant's construction and operation experience, in the context of mutual acceptance the **two-step licensing process** may also be used:

- The first step of 12-18 months would result in issuance of a construction licence; here, the regulator would look at the adaptation of the design to local specificities and organizational aspects and perform the environmental impact assessment. This would be followed by supervision of the quality of construction and testing.
- The second step would be for fuel loading or an operating licence, where the regulator would look at operational aspects and whether the licensee has taken sufficient design ownership to safely operate the plant.

Therefore the good practice licensing process should provide an applicant with a choice of a one-step or a two-step procedure.[24]

[24] This is actually the case in the US, where the "old" two-step licensing process (10 CFR Part 50) still exists alongside the new process, codified in 10 CFR Part 52, featuring the one-step combined construction and operating licence (COL). In the current practice, however, applicants choose only the new procedure. This seems to confirm the view taken here that the one step licensing is more suitable at least when it comes to licensing the first plants of a design.

c) Safety requirements: In this second phase, there is a strong need for convergence of safety requirements at least for important issues; the acceptance of a foreign design certification would not be possible if there were substantial differences in safety requirements between the two jurisdictions. Examples for issues which would need to be resolved internationally by then are: digital I&C and the necessity of a hard-wired backup; engineering principles applicable to measures for the mitigation of severe accidents; requirements applicable to the crash of a large-scale commercial aircraft on the NPP.

PHASE 3: ISSUE INTERNATIONAL DESIGN CERTIFICATION

a) Design review and approval: In this phase, design approvals would be given the shape of an internationally valid design certification. Design certifications might be issued by a team of all the regulators concerned. In a more long-term perspective, the certification could ultimately be issued through an international organization. The certification would be **applicable in all participating countries**. Once an international design certification has been issued, the task of national regulators would be focused on assessing the adaptation of the approved design to local circumstances, as described above in the definition of standardized designs, and supervision of construction, commissioning and operational activities. This would suppose a clear and firm international framework under which national regulators would, by participating in this system, endorse its conclusions. The EU, with its free circulation of goods certified to European standards, is a good example of such a framework.

Of course, the transition to such a framework involves a substantial change in the overall framework and subsequently in the task structure of all stakeholders - the designated group for issuing the international certificate, national regulators, vendors and licensees. During the preparation of this paper, a concern was raised that with the completion of Phase 3, national regulators would lose their competence and also their credibility vis-à-vis their governments and the national public. CORDEL Group fully acknowledges that **regulatory credibility in the nuclear field, which is highly susceptible to politics and to public concerns, is essential**. However, if the international design certification is issued by a team of all regulators, each regulator would still be fully involved in the design review. Besides, as has already been explained above, licensing of nuclear power plants comprises many other elements, including assessment of the design's applicability to local conditions, leaving a large scope of activities to national regulators, and opportunities to familiarize with detailed design features. If, in a more distant future, an international organization should be entrusted with issuing design certifications, competence and credibility would need to be invested into this organization and demonstrated by it towards governments and citizens.[25]

A current example, albeit of a very reduced scope and limited depth, of a design review having an international effect, independent of a national project, are the **IAEA Safety Review Services**, such as the Generic Reactor Safety Review (GRSR). Upon application by a Member State, a team of IAEA experts reviews a reactor design against the Agency's safety standards and issues a report stating whether or not compliance is reached. Of course today this is not comparable to a full-scope design review as performed by a national regulator, especially as the IAEA review does not consider any national safety requirements and does not have any binding effect on any national licensing procedure. However, to the extent national safety requirements would be aligned or harmonized, probably on the basis of IAEA safety standards, such an IAEA review could play an enhanced role and could be the nucleus of a future international design certification, as proposed for Phase 3.

[25] An example would be the European Aviation Safety Agency EASA, which has taken over some regulatory competencies from national regulators and is, for these issues, now accepted as a credible expert authority. For example, EASA issues Type Certificates, while the national aviation authorities are still responsible for certifying individual aircraft (the so-called Airworthiness Certificate) and licensing airlines.

b) and c) Licensing processes and safety requirements: A multinational validity of design certifications would suppose a common structure in national licensing processes and harmonization in safety requirements to a level of detail which is sufficient to describe the safety features of a standardized design.

OTHER IMPORTANT ISSUES

Cooperation in manufacturing oversight and inspection

The oversight of component manufacturing could be organized in a way that involves the regulators of all the countries for which such a component could be destined. CORDEL acknowledges the first steps taken toward this aim by the MDEP. In the medium term, it should be possible to establish agreements which would make it feasible for a national regulator to **accept an oversight performed by one of its peers**.

One of the main results of such a mutual acceptance would be that long lead equipment could be manufactured for standard design without yet knowing in which particular nuclear power plant project that particular component would be employed (**project-neutral manufacturing**). The advantages linked to such a concept are obvious: it would reduce manufacturing bottlenecks and lead to an improvement in quality and economics. Besides, it would reduce time pressure on manufacturers and regulators in case of deviations: especially long lead items are often on the critical path but the situation could be solved by taking an identical pre-fabricated component "from the shelf". Additionally, as is the case for the entire CORDEL concept, it would **increase regulatory efficiency** and effectiveness by leading to a suitable allocation of resources. There are a few examples from the past where project-neutral manufacturing has already been done[26], and there is an urgent need to move in this direction for some components today.

Cooperation with emerging nuclear states

There are several initiatives by the IAEA and by national governments and regulators of some experienced nuclear countries to **supply advice and support to emerging nuclear states**. As set out above, the aims of this document are in harmony with these efforts and could decidedly enhance their impact.

Conventional regulations and standards

A large part of the design of a nuclear power plant is done to non-nuclear regulations and standards which are not specific to nuclear facilities. These may diverge considerably from country to country. To give an example, the regulations on escape routes (maximum distance to the nearest emergency exit) or on the height of steps of emergency staircases might seem not too relevant, but they have an impact on the design of structures and buildings (the height of steps, for example, would influence the floor levels). Of course, there is no question of tackling the immense work of harmonizing all conventional standards just for the sake of nuclear power plants. Instead, **regulators should be prepared to accept designs based on standards of acknowledged industrial countries**, even if they diverge from their own national standards. If this is not possible due to legal and regulatory constraints, national legal or regulatory documents should be amended to allow for such an acceptance.

[26] For example, reactor pressure vessel heads have been fabricated for possible use in France, the US and South Africa.

7 How can the processes be started and who can contribute?

7.1 GENERAL

A stepwise integrated approach, as outlined above, would have to be implemented and supported by all stakeholders.

The **industry** and **regulators** would play a decisive role, especially at the outset. As indicated above, the goals of Phase 1 could be achieved largely by regulators within the existing legal framework.

For the goals of Phase 2, some action by **governments and regulators** is necessary, in order to create a framework to facilitate takeover of a foreign design approval and for national acceptance.

For Phase 3, action is necessary at the national and international level in order to create a legal and regulatory framework eventually to allow for international design certifications.

7.2 INDUSTRY

The contribution of industry has been outlined in section 5. The processes should be started right away. A sign of commitment of the nuclear industry to the aim of reactor standardization is the creation of the WNA CORDEL group which has developed this document. The CORDEL group represents the position of the major nuclear vendors worldwide and a number of nuclear utilities interested in the new nuclear build. So far, it has been working as a “think tank” and as author of several statements and papers and of contributions to conferences. Industry is prepared to provide CORDEL with additional resources, if needed, to support regulators, to promote standardization of designs and to take further steps towards strengthening best practice sharing and experience feedback mechanisms.

Furthermore, CORDEL could encourage international standard organizations to tackle the issue of international harmonization of safety standards and industrial codes and standards in the nuclear field.

7.3 REGULATORS

Regulators also have already begun to address some of the challenges mentioned here. The primary task of regulators is to ensure safety. This is in line with the aims of this CORDEL proposal: as CORDEL has already set forth in the "Benefits" paper mentioned in section 2, standardization and harmonization would enhance safety. Besides, the multiplicity of new nuclear power plant projects puts a strain on regulators which seems to require international cooperation in order to share the burden of design review. The implementation of the stepwise approach can therefore be seen as a means to improve regulatory efficiency and effectiveness.

The main regulators' initiative in this field is the **Multinational Design Evaluation Programme (MDEP)** which has already been described in section 5. MDEP is for the time being focused on increasing the level of cooperation, on leveraging resources and on identifying common regulatory practices. This represents great progress - which is fully acknowledged by CORDEL - but nevertheless it still falls somewhat short of mutual acceptance of design approvals as proposed in this paper. CORDEL therefore suggests **giving MDEP a more important and formally enhanced role**:

- MDEP should be backed by an intergovernmental agreement. This would give it more visibility and credibility. The international agreement could be crafted under the auspices of OECD-NEA, or the IAEA, or jointly by the two organizations.
- MDEP should accept the increase of its membership to the regulators of other countries embarking in new build.
- MDEP should be given more resources with eventually a dedicated staff in order to proceed more effectively and efficiently.
- MDEP should work on comprehensive design reviews and, as a product of this work, make proposals for harmonization of safety standards to its member states.

7.4 GOVERNMENTS

Governments and legislators would need to take a number of steps, both concerning national legislation and international agreements.

National Nuclear Energy Acts in some countries might require some modification to allow for an **adjustment of licensing processes** and for a **facilitated acceptance of foreign design approvals and foreign design standards**. Newcomer countries could draft their new nuclear policy acts giving consideration to the mutual recognition of foreign practices from the start. A good example for a legal provision paving the way for an acceptance is Italy's Act on Energy Companies as cited in Phase 2 (section 6).

Any national provision for such mutual recognition of foreign practices would have to be backed by **international or bilateral agreements**. First, there could be a set of agreements between states to allow for a facilitated takeover of a design approval issued in another state, as described in Phase 2 (section 6). At a later stage, international agreements could establish joint design approvals with applicability in all participating states, as envisaged in Phase 3.

On an international level, there would also be a need for **internationally agreed high-level safety goals**. The willingness and ability to achieve the creation of such an international nuclear safety framework is in the hands of national governments.

7.5 INTERNATIONAL ORGANIZATIONS

The IAEA could be a major driver and a forum for governments to take and coordinate the intergovernmental and regulatory initiatives outlined above.

Best practices in licensing, including an international coordination for design acceptance, could be spread via the IAEA's Integrated Regulatory Review Service (IRRS). The IAEA Generic Reactor Safety Review (GRSR), reviewing reactor designs against the Agency's safety standards, has already been mentioned. The role of the Agency in harmonization is also underlined by the enhanced importance of the IAEA safety standards themselves. The CORDEL group also recommends that the IAEA should produce a "validation guideline" as mentioned above. CORDEL, in return, offers its members' expertise to the Agency in support of the production of such a guide.

In the longer term, the IAEA could serve as an international body in a position to coordinate the implementation of an international design certification process for all new standard designs. If MDEP is going to be strengthened as proposed above, it should work in close cooperation with the IAEA.

7.6 OTHERS

A variety of international financial and business development institutions are aware of the importance of harmonization. First findings from discussions with financial institutions (for example within the European Nuclear Energy Forum) indicate that they would need to be assured that the licensing process for new nuclear power plants is predictable and that the licensing risk is perceived to be sufficiently low. The important development towards increased predictability would be to follow the stepwise approach to standardization outlined in this paper.

Generally, due to the complexity of the political and regulatory framework for the electric power industry, and especially for the nuclear industry, financial institutions are hesitant to invest in new power technology projects, especially in the nuclear sector, because it is difficult to assess the risks on the path to the project's completion. These risks could be significantly reduced by introducing standardization. It would lead to a simplification and, once the FOAK is shown to have been constructed to time and to cost, and, later on, to be operating successfully, **the financing of subsequent nuclear power plants following the same design would be much easier**.

Therefore, by involving financial institutions in the debate, the industry could gain an additional voice of support. On the other hand, it would also be necessary for financial institutions to acknowledge the benefits of standardization and to take these into account when taking a decision on financing a nuclear power plant.

8 Conclusions

Standardization of reactor designs is essential to enabling nuclear power to maintain and enlarge its role as a vital part of the global energy mix. Standardization is a task for the industry to achieve, and a result that the industry is poised to deliver. However, today the multiplicity of national regulations in regard to safety requirements and licensing processes prevents standardized designs from being deployed worldwide. Therefore, the WNA CORDEL group in this paper proposes a practical, three phase approach to the international standardization of reactor designs, certified in efficient, transparent procedures to harmonized safety standards.

The approach is stepwise, as there are three phases proposed in order to give a structure to the long road to standardization and harmonization. Some headway, in the first phase, could be achieved by all players within existing policy frameworks. For the second and third phase, some adaptations and innovations in industry policy, regulations, legislation, and international cooperation may need to be introduced.

The approach is integrated because the contributions of all stakeholders need to interlock: industry must bring to bear all benefits of standardization on nuclear safety and performance; governments and regulators must provide a framework to make this possible; international institutions and other stakeholders must provide their contribution and acknowledge the results.

Following this approach will yield the benefits of standardization for the worldwide deployment of nuclear power in the safest and the most efficient manner possible.

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The World Nuclear Association is the international private-sector organization **supporting the people, technology, and enterprises** that comprise the global nuclear energy industry.

WNA members include the full range of enterprises involved in producing nuclear power – from uranium miners to equipment suppliers to generators of electricity.

With a secretariat headquartered in London, the **WNA serves as a global forum** for industry experts and as an authoritative information resource on nuclear energy worldwide.

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