New nuclear build and evolving radiological protection challenges

by T. Lazo

Many trends and indicators suggest that the use of nuclear power for generating electricity will increase, perhaps significantly, in the coming 10 to 20 years and beyond. Any such expansion will not take place in a static scientific or social context, but rather in the midst of ongoing changes in many relevant fields, radiological protection, radioactive waste management and nuclear safety to name a few.

Regarding radiological protection, this evolution can be characterised in many different ways, but can conveniently be described as having scientific and socially driven aspects. These may well pose challenges to radiological protection (RP) policy, regulation and application in the future.

Evolution in radiological protection and new nuclear build

Over the past 20 years, the system of radiological protection has evolved significantly, in terms of both scientific understanding and the social aspects of decision-making. The scientific underpinnings of radiological protection continue to progress and ongoing studies pose scientific questions that deserve attention (NEA, 2007a). In parallel, given the non-absolute certainty of science and the judgemental nature of defining what is "safe enough", decision-making has become much more concerned with stakeholder engagement (NEA, 2007b).

Radiological protection challenges will certainly be encountered in the context of new nuclear build. However, approaches to meeting these challenges are not unique to new construction projects. Innovative yet sustainable approaches will be needed in addressing many radiological protection decision-making situations in the future, whether associated with existing or new facilities. Overall, to make progress on radiological protection issues it will be necessary to have transparency in decision-making structures and processes, to use state-of-the-art science and to engage with stakeholders.

In the context of new nuclear build, this translates into several levels of discussions and decisions. At the uppermost level, many governments have or will address the utility of nuclear energy in their overall energy mix. This is in essence a decision in the area of justification, and will be addressed at the national level according to national laws, legislation and traditions. It is difficult to see, however, how such decisions could be taken without some level of "public debate". At a lower level, decisions will be needed with regard to specific siting of new plants. Here again, national level laws and legislation will define the consultation and decision-making processes that will be used, and the more clearly these are defined and broadly understood, the more smoothly they will proceed.

Although most radiological protection decisions are not driven primarily by science, it evidently plays a key role in framing decisions that need to be made. In this context, it is essential that state-of-the-art science is used as the foundation for assessing radiological risks, keeping in mind, nevertheless, that science in general carries a fair amount of uncertainty. Hence, some judgement will be necessary when deciding whether, and if so how, uncertain scientific knowledge should be taken into account when applying a precautionary approach. The "tipping point" at which new science should induce change in RP approaches is a difficult, judgemental choice that will be very case-specific.

In the particular case of new nuclear build, while the evolution of new scientific knowledge does not seem to imminently call for change in RP approaches, there are clearly areas where scientific results *could* affect the way that radiological protection is structured and applied. For the moment, most of these questions are more in the "what if" stage, although this status does not dismiss the issues. Rather, it is suggested that scientists and regulatory authorities should increase their communication so that, as various aspects of this scientific research begin to reach closure, more detailed thinking as to the regulatory and practical implications of possible results could be undertaken in an open and transparent fashion.

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Practical considerations for new nuclear power plants

It will also be important for new nuclear build to appropriately incorporate and implement lessons learnt from successful nuclear reactor operation. These include experience with exposure trends, but also with "good practice". Both of these aspects can be included at the planning stage in order to ensure that worker and public exposures from new nuclear power plants are as low as reasonably achievable (ALARA) (NEA, 2010).

Incorporating operational RP lessons learnt into the design

An important lesson learnt during the last decades is that a substantial amount of exposure in past decades has resulted from lack of attention during design. Factors such as nuclear safety and operational availability have traditionally dominated design and construction phases of nuclear power plants, with operational RP aspects often addressed to a lesser degree. There is, however, a significant potential to avoid radiation doses, as well as long-term maintenance costs, if operational radiation protection experience is embedded in the architectural design and construction of new plants (e.g. integrated ladders/stairs instead of mobile scaffolds, easily accessible cable tunnels, in-duct laid pipelines, etc.). The fact that new plant designs are targeting 60 years and more of operational lifetime adds further incentive to carefully assess and incorporate in design effective and efficient features for dose reduction and plant productivity (e.g. some maintenance operations could be performed even when the reactor is operating, or with a reduced shutdown time).

A recently published NEA study on operational RP lessons (NEA, 2010) has identified several "guiding principles" that are seen to be crucial for the successful integration of lessons in planning:

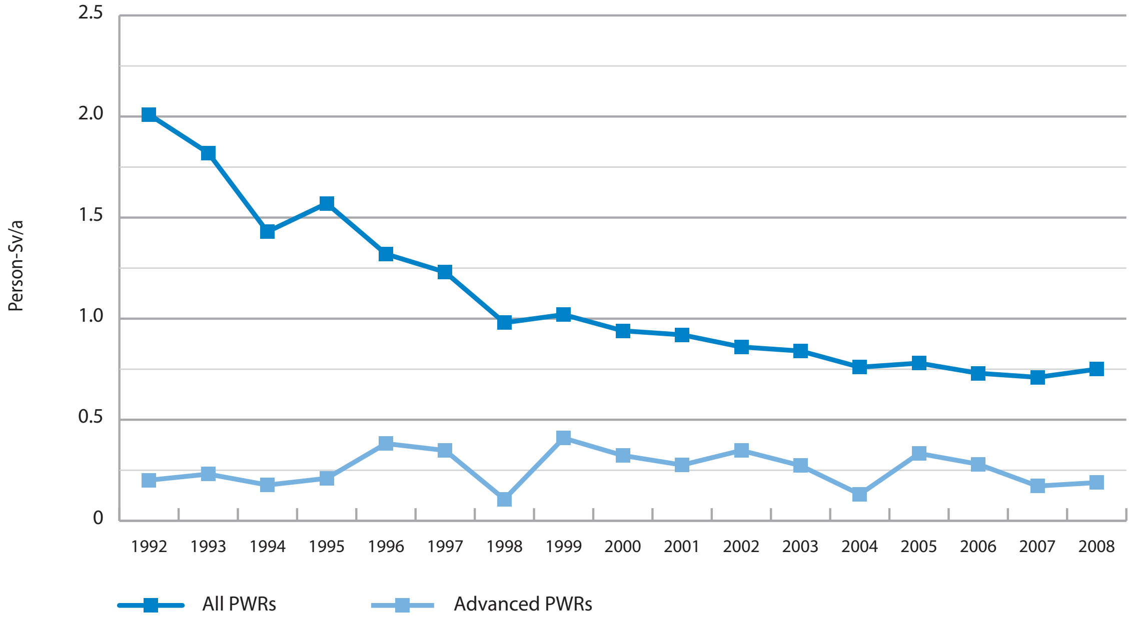
- *Proactive implementation of lessons learnt:* Crucial decisions affecting future radiation exposure of workers and also long-term expenses for maintenance, outages and modifications should be made during the design phase of a new nuclear power plant. Both radiation doses and costs can be reduced over the life cycle of the plant when practical experience from decades of operational RP in existing power plants is included in the architectural design at an early stage. It is also recommended to anticipate potential occupational exposure for the full life cycle of the plant (i.e. from operation to decommissioning) and to take optimisation measures in advance.
- *Balance of risks and allocation of resources:* Radiation exposure is not the only risk to be considered when designing a new plant. The allocation of resources for occupational health and safety at the design phase should be based on a rational balance aimed at optimising protection against all risks to workers.
- *Effective communication in optimising design:* Licensing requirements for safety and protection of the public and the environment may require technical and organisational measures that increase radiation exposure of workers. The designer and operator must understand regulatory requirements and how those requirements are interpreted for surveillance, inspection and other activities during the plant's operating phase. Having that clear understanding enables the designer to develop means and to use design elements that reduce radiation exposures. This requires close co-operation between regulators, designers and operators, as well as transparent and active consultation with other stakeholders.
- *Recognisable and effective operational RP:* The concept of operational RP should be forward-looking, addressing all phases of the life cycle of the power plant in order to demonstrate effective management and confidence. This should be supported by the full pool of operational experience. The management must always be aware that if the handling of operational RP appears negligent in the public's or the regulator's view, then trust in nuclear safety and in the reliability of management is put at risk. This jeopardises not only the operational availability of the plant but also nuclear technology as a whole.

Exposure benchmarks

Since about 1990, the average annual collective dose at nuclear power plants has fallen by more than a factor of two. For pressurised water reactors (PWRs), this evolution is from just over 2 person-Sv/a per unit to under 0.75 person-Sv/a per unit. For boiling water reactors (BWRs), the decrease is slightly less, from about 2.6 person-Sv/a to 1.5 person-Sv/a per unit. For new-generation PWRs, the current annual collective dose is closer to 0.25 person-Sv/a per unit. These collective dose trends are shown in Figures 1 and 2. The advanced PWRs represent the latest French and German designs, whereas the PWR and BWR single-unit averages represent all plants of these types in the world.

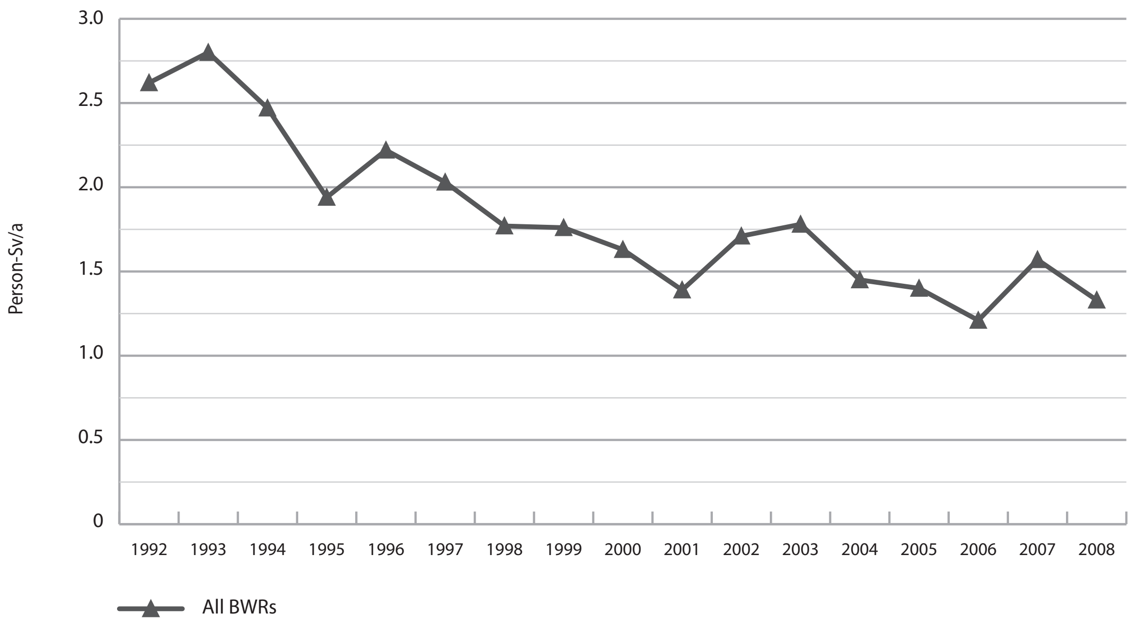
Given these trends, it seems reasonable that utilities wishing to build new nuclear power plants, and regulatory authorities involved in assessing license applications for new nuclear plants, would take this experience into account in establishing exposure benchmarks. For example, experience may be of use to establish, for planning purposes, annual collective dose benchmarks for new units, which could be on the order of 0.25 person-Sv/a for PWRs. Benchmarks for BWRs should be somewhere below about 1.5 person-Sv/a, but further data is needed in order to make a more accurate assessment. Based on current good practice and experience, such criteria could be useful in identifying the most appropriate protection options.

Figure 1: Average annual collective dose trends for all PWRs and advanced PWRs



Source: OECD/NEA Information System on Occupational Exposure (ISOE), 2008.

Figure 2: Average annual collective dose trends for BWRs



Source: OECD/NEA Information System on Occupational Exposure (ISOE), 2008.

Designing for public and environmental protection

In terms of public exposures and environmental protection, the management of radioactive emissions from nuclear power plants continues to be a priority and is the subject of an ongoing study at the NEA. Assessed public exposures from gaseous and liquid emissions from nuclear power plants remain well below the 1 mSv/a dose limit. Traditionally, effluents have been managed through a focus on optimisation and applying best available techniques (BAT). However, the results of effluent management continue to show wide variation, even among very similar plants. Tritium has been seen to vary by more than a factor of two among sister-plant units (identical units, often at different sites), and iodine-131 by over four orders of magnitude. In this context, it is difficult to judge what would be used as a "benchmark" for optimum management of effluents for new nuclear power plants, and as such how the regulatory limitation of discharges should best be accomplished.

One approach taken to the regulatory limitation of discharges has been the establishment of "discharge limits" or "licensing technical specifications" that limit the total activity released per year, and perhaps also place limits on the discharge rate. Such limitation values have traditionally been set at higher levels than the actual discharges themselves. This "operating overhead" gives the operator flexibility to cope with non-routine events, unplanned maintenance and minor deviations from the design parameters. However, if the operating overhead is too large, there is reduced pressure for optimising, and the "apparently high" limitation values can lead to presentational difficulties, since in theory they give an operator the right to discharge much greater quantities of radioactivity than they actually do in practice. Too low an overhead may result in operators breaching a limit when carrying out reasonable and necessary activities, even if such emissions would have arguably negligible radiological impacts. This too may lead to presentational difficulties, since a breach of a licence technical specification implies inadequate performance and could call into question the quality of regulatory oversight. The challenge is to devise a transparent and consistent approach to setting levels that are stringent enough to guarantee a high level of performance in relation to discharges, whilst giving operators the flexibility they need to conduct normal, acceptable operations without infringing their discharge authorisations. In principle:

- Discharge limitation should be based on the minimum level of discharge that the operator has justified the need for in order to operate the plant.
- Limitation should provide necessary headroom based on operational fluctuations or trends in the level of discharge over the year that the operator has substantiated may occur in normal operation, even though optimisation and BAT have been applied.
- The headroom allowed between actual discharges and limiting values is kept to the absolute minimum strictly necessary for the normal operation of the plant.

In this context, it should be noted that limiting values are not set at levels corresponding to the boundary between acceptable and unacceptable radiological impact. In particular, they do not correspond to the dose limits or constraints contained in national or international legislation. Indeed, the application of optimisation and BAT at the planning stage should have eliminated any proposals which would give rise to doses approaching or exceeding such limits or constraints before the discharge limit-setting stage is reached.

Conclusions

The construction of nuclear power plants has always raised issues of public concern. Even in the current climate in which nuclear energy is being seriously reconsidered in many countries at national government level and at multinational corporate level, the construction of new units has always raised questions that need to be resolved. Experience has shown that in such situations, decisions acknowledged as acceptable can take some time to be reached. To appropriately prepare to address questions of new nuclear build, governments should ensure that their established decision-making processes clearly and unambiguously lay out rules and responsibilities, and actively and effectively engage with stakeholders in gathering their views. The overall process will involve the use of state-of-the-art science and a statement of values applied when making judgements. Industry will need to ensure that its proposed facilities incorporate radiological and other lessons learnt, and to demonstrate that optimisation and work-management experience has been effectively applied to new plant designs, procedures and processes.

References

NEA (2007a), *Scientific Issues and Emerging Challenges for Radiological Protection: Report of the Expert Group on the Implications of Radiological Protection Science,* OECD, Paris.

NEA (2007b), *Radiation Protection in Today's World: Towards Sustainability,* OECD, Paris.

NEA (2010), *Occupational Radiological Protection Principles and Criteria for Designing New Nuclear Power Plants,* OECD, Paris.