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Initial Views on the Review and Revision of the System of Radiological Protection

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COMMITTEE ON RADIOLOGICAL PROTECTION AND PUBLIC HEALTH

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The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD analyses in areas such as energy and the sustainable development of low-carbon economies.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

COMMITTEE ON RADIOLOGICAL PROTECTION AND PUBLIC HEALTH

The objective of the Committee on Radiological Protection and Public Health (CRPPH) is to assist NEA member countries in the implementation and enhancement of the system of radiological protection. This objective will be met by identifying and effectively addressing those conceptual, scientific, policy, regulatory, operational and societal issues that either favourably or adversely affect the system of radiological protection, thereby promoting national and international good practices and identifying potential weaknesses and vulnerabilities.

To accomplish this, the Committee will contribute to the adoption and the maintenance of high standards of protection for the public, workers and the environment in all activities involving the use of ionising radiations, and particularly, but not limited to the field of nuclear energy.

In this context, the Committee on Radiological Protection and Public Health (CRPPH) shall:

- Provide a forum for the exchange of information and the transfer of experience between national radiological protection authorities on policies, regulatory issues and approaches, and their implementation in the context of realistic radiation exposure conditions, and as appropriate, the risks and regulatory arrangements for other common hazards.
- Seek international understanding and guidance, in support of national authorities, on questions of common concern regarding the interpretation and implementation of the ICRP recommendations and international standards in various fields of application of radiological protection, to contribute to the development of co-ordinated approaches among member countries, and to support the development of new international standards.
- Advance concepts and policies which make the system of radiological protection clear, transparent and adaptable to the broader social dimensions of decision making in complex situations, and further facilitate effective engagement with relevant stakeholders, including their involvement in decision making as appropriate.
- Promote international collaboration on specific radiological protection and radiation-related public health topics of interest to the NEA member countries in the framework of the NEA Strategic Plan.
- Keep under review, contribute to the advancement of, and identify needs for the state of the art in the field of radiological protection at the social-scientific, natural-scientific and technical levels, and promote the preparation of authoritative advice and reference documents, for use by national authorities, policy makers and practitioners, on emerging policy, regulatory and operational issues, and in those areas where international consensus on radiological protection concepts, regulatory issues and practices is sought.
- Help ensure the management of radiological protection knowledge and experience between generations of radiological protection experts.
- Actively interact with the International Commission on Radiological Protection (ICRP) to help link national policy and regulatory needs to the development of international recommendations.

In the fulfilment of its mandate, the CRPPH will work in close co-operation with other NEA Committees as appropriate, particularly the Committee on Nuclear Regulatory Activities (CNRA), the Radioactive Waste Management Committee (RWMC), and the Nuclear Law Committee (NLC), as well as with NEA divisions, and competent bodies within relevant OECD directorates and other international organisations active in the field.

Foreword

The goal of the Nuclear Energy Agency (NEA) Committee on Radiological Protection and Public Health (CRPPH) is "to assist member countries in the policy, regulation, implementation and further development of the system of radiological protection by identifying and effectively addressing conceptual, scientific, policy, regulatory, operational and societal issues" (NEA, 2022a).

The Expert Group on International Recommendations (EGIR) was re-established by the CRPPH in June 2021 to evaluate the International Commission on Radiological Protection's (ICRP) proposed review of the system of radiological protection as documented in Publication 103 (ICRP, 2007), and its subsequent publications. To this end, the EGIR supports the CRPPH mandate in promoting international collaboration on specific radiological protection and radiation-related public health topics of interest to the NEA member countries.

This report sets out the EGIR's initial views on the review and revision of the system of radiological protection. These views reflect the knowledge and experience of the members of the EGIR and of the CRPPH, and are based on a review of existing literature, including relevant NEA and ICRP publications issued since 2007. This report concludes the first phase of the EGIR's work plan, and will form the basis to recommend areas for further research and analysis to be conducted in 2023 and beyond.

Overall, members of the CRPPH and of the EGIR have welcomed the ICRP's decision to review and refresh the system of radiological protection. Their feedback on the process being adopted by the ICRP was particularly positive. They acknowledged the openness and transparency that the ICRP is promoting and the ambition to engage with a wide variety of stakeholders. The EGIR's initial view is that the current system of radiological protection, as recommended by the ICRP, has contributed substantially to the provision of radiation safety and protection. The process of reviewing and revising the system should be seen as an effort to enhance it and adapt to changes in the prevailing circumstances rather than a significant overhaul. This report discusses the areas of the system of radiological protection that could benefit from ongoing improvement. It includes a review of the overarching system of radiological protection, optimisation, environmental protection, radiological detriment and risk, exposure situations and several cross-cutting issues, such as ethical considerations, communications and low-dose research. The ICRP review should demonstrate the net benefit of any proposed changes for stakeholders.

Acknowledgements

This report was prepared by the Nuclear Energy Agency (NEA) Expert Group on International Recommendations (EGIR) and endorsed by the Committee on Radiological Protection and Public Health (CRPPH). The NEA thanks the members of the EGIR for their involvement and contributions to ensure the fulfilment of this first phase of the CRPPH and EGIR's contribution to the ICRP's review and revision of the system of radiological protection. In particular, the NEA and CRPPH would like to recognise the efforts of Sigurður Magnús Magnússon (Iceland), Chair, in addition to the expert members of the EGIR, Christina Dodkin, Debora Quayle (Canada), Stefan Mundigl (European Commission), Mika Markkanen (Finland), Anne Cordelle, Caroline Schieber, Laurent Bodin (France), Augusto Giussani, Silke Neveling, Ulrike Kulka (Germany), Marie-Claire Cantone (Italy), Haruyuki Ogino (Japan), Odd Runevall (Sweden), Graham Smith, Kate Griffith (United Kingdom), plus invited expert Peter Bryant (World Nuclear Association).

The work to produce the present EGIR report was supported by Christopher Mogg, Radiological Protection Specialist within the NEA Division of Radiological Protection and Human Aspects of Nuclear Safety, which acts as the NEA EGIR Secretariat, together with Jacqueline Garnier-Laplace, Deputy Head of the same division.

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List of abbreviations and acronyms

CDLM	Committee on Decommissioning of Nuclear Installations and Legacy Management (NEA)
CRPPH	Committee on Radiological Protection and Public Health (NEA)
CT	Computed tomography
DALY	Disability adjusted life years
DC	Dose coefficient
DCRL	Derived Consideration Reference Levels
DDREF	Dose and Dose Rate Effectiveness Factor
EGIR	Expert Group on International Recommendations
HDCS	Expert Group on a Holistic Process for Decision Making on Decommissioning and Management of Complex Sites (NEA)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ISOE	Information System on Occupational Exposure (NEA)
NEA	Nuclear Energy Agency
QALY	Quality adjusted life year
RAPs	Reference Animals and Plants
RBE	Relative Biological Effectiveness
RP system	Radiological protection system, as defined by the ICRP
SLO	Special Liaison Organisation
TG	Task Group

Executive summary

The Expert Group on International Recommendations (EGIR) was re-established by the Nuclear Energy Agency (NEA) Committee on Radiological Protection and Public Health (CRPPH) in 2021 to evaluate the International Commission for Radiological Protection's (ICRP) proposed review of the system of radiological protection as documented in Publication 103 (ICRP, 2007) and its subsequent publications. The ICRP has invited open and transparent engagement in the process of reviewing Publication 103, which will take several years to complete (Clement et al., 2021). The EGIR, operating under the CRPPH, will co-ordinate the collective reflection of the NEA member countries on this process.

The EGIR's initial view is that the current system of radiological protection, as recommended by the ICRP, has contributed substantially to the provision of radiation safety and protection. The process of reviewing and revising the system should be seen as an effort to enhance it and adapt to changes in the prevailing circumstances rather than a significant overhaul. With this in mind, the early work of the EGIR focused on areas within the current system where improvements could be achieved. This led to five priority themes that the EGIR targeted for its initial review. Under each priority theme, the group considered the key issues, problems encountered and recommendations for addressing the key issues. These are summarised as follows:

Theme 1: The system of radiological protection

This overarching theme explores two key issues that the EGIR believes should be addressed as part of the proposed review: (1) the need to gain a firm understanding of how, and to what extent, the current system has been applied and how effective this has been in improving radiological protection; and (2) the need to provide clear evidence of how any proposed changes to the system of radiological protection lead to proportionate overall improvement to the delivery of radiation safety, human health (members of the public, workers, patients) and environmental protection.

Theme 2: Optimisation

In many cases, optimisation is the key principle in achieving radiological protection across all exposure situations; however, several questions remain to be addressed when considering the practical application of the optimisation principle. For example, key issues for improvement are: how to develop an optimisation process that considers holistic risk assessments, including other non-radiological risks, how to ensure reasonableness is integrated, and how to include stakeholders effectively into a robust decision-making process.

Theme 3: Environmental protection

Since the release of Publication 103, the field of environmental protection with regard to ionising radiation has developed significantly, notably with Publication 108 and its companion publications. In light of the approach developed to demonstrate protection of the environment since Publication 103, the EGIR strongly recommends that the ICRP separate the discussion on non-human biota into two categories: (1) natural environment and wildlife, and (2) domesticated species and veterinary patients. There is also a need for the RP system to have a greater focus on sustainability, climate change and ecosystem services, in line with the UN sustainable development goals.

Theme 4: Radiological detriment and risk

The ICRP's proposal to reassess the current estimates of detriment using updated data sets and the latest scientific findings is welcome. Explicitly considering age, sex or other characteristics in the calculations of detriment, prior to simplification, will improve transparency. Revisiting the health outcomes that are already included (cancers, possibility of heritable effects) or potentially to be included (non-cancer diseases such as circulatory diseases or eye lens opacities) will support alignment with the best available evidence. At the same time, the EGIR has concerns that the application could lead to practical and/or ethical challenges, complicating a concept that is already frequently misunderstood. It is therefore essential that the ICRP provide more information to support the interpretation and use of detriment and detriment-adjusted risk in language suitable for professional and non-professional audiences.

Theme 5: Exposure situations

The move to a situation-based protection approach in Publication 103 brought with it a number of benefits and challenges from a practical radiological protection perspective. As the approach continues to evolve, it is necessary to address several persistent issues, such as clarifying how to apply the optimisation principle across the different exposure situations, how to transition between exposure situations (e.g. from an emergency exposure situation to an existing exposure situation, and the possibility of transitioning from an existing exposure situation to a planned exposure situation), and how to apply the concepts of limits, constraints and reference levels, depending on the circumstances.

The work of the EGIR supports the CRPPH in providing a clear, comprehensive and representative opinion to the ICRP. This is intended to support the ICRP's work in gathering the evidence required to substantiate, or where necessary challenge, any proposed changes to the current system of radiological protection. In addition to the initial views highlighted, it is anticipated that new and emerging issues will arise throughout the long-term review process, which may require updates and additions to this report.

1. Introduction

Background information

Co-operation with the ICRP has always been a pillar of the NEA programme of work, directly in a bilateral form or indirectly through the feedback from the NEA's 34 member countries on the system of radiological protection (hereinafter referred to as RP system) and underlying science, its translation into regulations, standards and guidance, and in its implementation and related practices. The NEA's Committee on Radiological Protection and Public Health (CRPPH) has contributed, through a variety of mechanisms for sharing experience and in-depth reflection, both to the evolution of the RP system and to the improvement of its application by identifying new and emerging challenges, solving problems and identifying good practices.

In the CRPPH paper entitled "Statement on the possible role of the NEA and its Committee on Radiological Protection and Public Health in the review and revision of the System of Radiological Protection" (NEA, 2021a), the NEA proposed a four-step process to contribute to the revision of the ICRP system:

(1) Re-establish the Expert Group on International Recommendations (EGIR), which will collect initial thoughts on the changes needed to the system and suggestions on the way forward, including research priorities;

(2) Collect feedback from the CRPPH's planned, ongoing or recently completed working groups on their views on the system in their specific area of work (low-dose research co-ordination, dose limit to the lens of the eye, preparedness for post-accident recovery, post-accident food safety framework, mental health and psychosocial impact in decision making of the protection strategy, knowledge management, etc.);

(3) Develop a document compiling the views expressed by experts on the changes requested, their justification and the suggested way forward;

(4) If necessary, propose specific working groups or events to take forward some of the findings, in conjunction with the ICRP and other relevant organisations.

This report, which is the output of steps 1-3 in the process above, sets out the initial thoughts of the CRPPH and EGIR on the changes to the ICRP system of radiological protection and provides an overview of working methods employed. It includes feedback received from a topical session held at the 80th meeting of the CRPPH in March 2022 (CRPPH-80).

The next steps (step 4 above and beyond) will be to recommend areas for further research and analysis to be conducted in 2023 and beyond. This may include suggestions for key topics to be further investigated through specific expert groups, events such as workshops in consultation with the ICRP, or surveys. A similar approach will be taken to the previous revision of the RP system, which covered why and how the changes from the ICRP Publication 60 (ICRP, 1991) led to the ICRP Publication 103 (2007), as documented in the report *The NEA Contribution to the Evolution of the International System of Radiological Protection* (NEA, 2009). Communications will be maintained with internal and external stakeholders to ensure that wider views are considered, including through close collaboration with ICRP Special Liaison Organisations (SLOs).

Overview of the working methods of the EGIR

The early work of the EGIR has been focused on prioritising areas where changes to the current RP system could lead to overall improvements. Ahead of the kick-off meeting, EGIR members were asked to review the ICRP paper "Keeping the ICRP Recommendations fit for purpose" (Clement et al., 2021) and provide a short summary outlining the top three issues they would like to see addressed by the review of the RP system. As such, several themes emerged that the EGIR took forward as priority issues to be considered for initial review. These were selected on the basis that multiple EGIR members raised the issue in their independent submissions. Other themes, including cross-cutting issues and additional topics raised by the CRPPH, as set out in Appendix A, will be covered under the five prioritised themes or tackled separately at a later stage (see section 6 of this report).

The priority themes that the EGIR has concentrated on in this initial phase include:

1. The system of radiological protection as a whole (RP system)
2. Optimisation
3. Environmental protection
4. Radiation detriment and risk
5. Exposure situations

General views of the EGIR:

The ICRP's decision to review and refresh the RP system is welcomed by the NEA CRPPH, and the feedback received from EGIR members on the process being adopted was positive. There was, in particular, an acknowledgement of the openness and transparency that the ICRP is promoting and the ambition to engage a wide variety of stakeholders. In general, the EGIR feels that any changes to the system should be seen as an exercise in continuous improvement rather than a significant overhaul of the process.

The EGIR supports the drive towards simplifying the current RP system and improving the clarity and consistency of communications; however, this must be treated with caution as there is a risk that over-simplification could result in adverse or unexpected effects. Any changes must be based on the state of the art in science and technology and take account of the wider social, environmental and economic issues at stake, including consideration of non-radiological risks. The EGIR is particularly keen to stress that changes to the RP system must be supported by clear evidence of the net benefits for stakeholders[1], i.e. in terms of the net benefits for human health, the environment or the practical implementation. The benefits/impacts of proposed changes are a key part of the review and are addressed further in section 1 of this report.

The views expressed in this paper under the five themes highlight the early thoughts of the CRPPH and EGIR and provide a brief summary of the issues at stake. The views presented will require further analysis, which will be addressed in 2023 onwards by specific groups and events led by the CRPPH in consultation with the EGIR, other NEA Standing Technical Committees, the ICRP and ICRP SLOs. Additional items for consideration are presented in section 6.

1. "Stakeholder" is intended to be taken in its broadest sense and should include the public, businesses, economic actors, non-governmental organisations, local, regional and national authorities and others, such as academia (NEA, 2017).

2. The system of radiological protection (RP system)

The ICRP's system of radiological protection (RP system) has been central to international radiological protection theory and practice for decades. The first General Recommendations were produced in 1928 (ICR, 1929), with subsequent updates produced, prior to the current practice of numbering publications, in 1931 (ICR, 1931), 1934 (IXRPC, 1934), 1937 (IXRPC, 1938), 1950 (ICRP 1951), 1954 (ICRP, 1955), and 1956 (ICRP, 1958), and then in ICRP Publications 1 (ICRP, 1959), 6 (ICRP, 1964), 9 (ICRP, 1966), 26 (ICRP, 1977), 60 (ICRP, 1991), and 103 (ICRP, 2007) (cited in Clement et al., 2021). The RP system has continuously improved over time and it is felt that it is currently an effective system for radiation safety and protection of people and the environment. Any improvements should be targeted on efficiencies, state of the art science, ethical values and generating benefits for the end-users (e.g. regulators, industry, workers, patients or the general public) and environment. In this context, it is important to note the broad span of the RP system and the holistic approach that should be advocated. For example, Publication 138 states "scientific facts are essential to understanding, but, alone, are not enough to decide what to do. Ethical values are the other ingredient necessary for making recommendations on how to behave in light of our scientific knowledge. ICRP also relies on experience to help make recommendations practical" (ICRP, 2018).

Key issues

There are two key issues that should be addressed as part of the proposed review: (1) the need to gain a firm understanding of how, and to what extent, the current RP system has been implemented and how effective this has been in improving radiological protection; and (2) the need to provide clear evidence that demonstrates how any changes to the RP system lead to proportionate overall improvement to the delivery of radiation safety, human health and environmental protection.

The first issue calls for a better understanding of how the existing recommendations in Publication 103 have improved or detracted from radiation safety, including radiological protection. This includes the changes to international treaties, conventions, standards, recommendations and guidance, as well as corresponding changes at the national level in policies with strategies for their implementation, and corresponding laws, regulations and regulatory processes that have been made as a result of the ICRP recommendations. This should include an understanding of why some countries have yet to introduce the changes made in Publication 103 into their national regulatory frameworks, and what the associated barriers to implementation are. Is it simply that it takes a period of time to install change or was it decided not to apply the recommendations? Without this understanding, it will not be possible to identify the need for possible corrections, revisions and additions to the current RP system and how they should be addressed.

The second issue is fundamental to ensuring that any changes made to the current system result in an overarching net benefit for stakeholders. As the review progresses, it will be necessary for the ICRP to strive towards a global consensus for the proposed changes and clearly demonstrate and document the net benefits of revisions to the current RP system. This should include consideration of the application and practicalities of transposing them into regulatory frameworks. The RP system will also need to be able to address and adapt to future changes, for example evolutions in state-of-the-art science, new technologies, potential large accidents, wide-scale decommissioning of reactors and external factors, such as societal changes (i.e. lifestyle and population), climate change and ethical views.

This calls for an RP system that is flexible to accommodate changes over the next one or two decades of its anticipated life cycle.

Problems/challenges encountered

The two key issues set out above have many associated issues that will need to be addressed as part of the review. One area where greater clarity is required is the interaction between the three fundamental principles of justification, optimisation of protection and dose limitation. For example, the current RP system introduces the fundamental principles as three separate issues to be applied in a distinct sequence: 1) assess justification, 2) if justified, optimise protection, and 3) ensure that dose limits (where applicable) are not exceeded. However, in practice, the three principles are not always applied separately and in that sequence because assessment of justification always involves some estimation of the dose, which is likely to already include some level of optimisation. In addition, dose limitation may be considered upfront: if dose limits are likely to be exceeded, the practice could be deemed unjustified without any further considerations. Such discrepancy between the theory/philosophy of the system and its practical implementation leads to challenges in understanding the system and communicating it transparently to stakeholders.

As part of the review of RP system, it will be important that any changes do not affect the current distinction between the role of the ICRP alongside other key international bodies, such as the NEA, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), IAEA, World Health Organization (WHO), International Radiation Protection Association (IRPA) and International Labour Organization (ILO). This would also benefit from clarifying and documenting these interactions and distinctions during the review process to ensure that all stakeholders have a clear understanding of the various roles and responsibilities. Further to this, greater clarity could be gained by using this as an opportunity to explain the hierarchy and links between ICRP publications. For example, ICRP has produced over 40 publications since Publication 103 was issued and it would be useful to provide clarity on how such publications, and the recommendations within them, should be implemented when reading across documents.

Any changes that are recommended during the review must be supported by a detailed analysis of the benefits and impacts. Implementing the changes will likely require resources from stakeholders such as regulators and industry, which further highlights why providing evidence of the clear benefits is necessary. Sectors are also likely to evolve: for example, the medical sector will develop rapidly with new treatments using novel radionuclides, as well as rapid growth of all medical procedures in an ageing and wealthier population. The nuclear industry is also likely to evolve over the next two decades in line with the decommissioning of existing reactors and move towards advanced nuclear technologies. Climate change will in all likelihood present greater health and environmental risks, which need to be accounted for in future decision making, along with other factors, such as sustainability, ecosystem services and increased stakeholder engagement, as these will be key issues when considering future needs. It is therefore essential that the RP system be set up to adapt to such changes and prevailing circumstances.

Addressing the key issues

The simplification of the RP system is welcome and should be a clear objective of the review across all of the themes raised in this report. Simplification is a particularly important aspect of communicating the system to stakeholders, including the public, and increasing understanding. It will be necessary to take an in-depth look at Publication 103 to see where the current system can be simplified, including by providing explanations of some of the historic elements, providing evidence of the scientific basis, and giving feedback on its application worldwide.

As part of the drive towards simplification, it must be evaluated how much added value would be gained from this exercise. The scientific evidence and arguments that support the management of human health and environmental protection are complex, but the parts that are actually applied for the purpose of radiological protection must be comprehensible to everyone (i.e. by concentrating on simplifying the user-interface parts). This includes terminology for terms that are internationally common to health, safety and the environment, such as the definition of health used by the WHO, but also harm, hazard, risk, and the links with UN sustainable development goals (United Nations, 2015).

Any additional complexity to the existing RP system and changing any part of Publication 103 that would not result directly in a clear and proportionate overall improvement in the safety and protection of human health and the environment should be avoided. To develop the understanding required from the start to focus on matters that affect safety and protection, it is necessary to answer the following questions:

- Where changes have been introduced[2] in line with Publication 103, have they had a demonstrably positive effect on safety and protection, and
  - if so, what were they? And;
  - if not, what were the problems introduced (or were still present from previous versions)?
- Have the changes had other benefits or impacts on human health and the environment in the context of overall (not just radiological) optimisation and decision making?
- If changes have not been made in line with Publication 103, why were they not made and what are the consequences on safety and protection?
- What advances in science have been made since Publication 103?

The review and analysis of the current system can be done in parallel with the revision, but should be completed before proposed changes are finalised. This will ensure these have built-in consideration of the expected consequences rather than the analysis being only a check made too late to stop the momentum. The scope of consequences should include radiological matters but also any factors that impact upon optimisation, including a holistic view of non-radiological impacts on human health and the environment[3.] Some flexibility will be needed when proposing amendments to allow for continuing changes in science and society, including changes in ethical values, and developments in documents from other international organisations, especially the NEA, UNSCEAR, IAEA and WHO.

2. Refers to changes to international treaties, conventions, standards, recommendations and guidance; and corresponding changes at the national level in policies, strategies for implementation of policy, and corresponding laws, regulations and regulatory processes, and practices. It is recommended that analysis is carried out on several of the key recommendations from Publication 103 (ICRP, 2007) (e.g. categories of exposure, protection of the environment or exposure situations) to provide a high-level examination of how the current these have been implemented.

3. During the longer-term review it will be necessary to define the term "holistic" to ensure that, in addition to human health or more broadly wellbeing, it addresses the social, environmental, and economic aspects that need to be considered in the application of the fundamental principles.

There is a need to review how the principles of justification, optimisation and limitation are applied and whether the current sequence of application is suitable for all practical applications. The practical application should be a key consideration along with ethical values, which should be seen as core components of the fundamental principles and drivers to help reassess the fundamental principles. These will also need to be checked for consistency with overarching international goals, such as the UN sustainable development goals.

It is essential that any changes to the RP system include elements and tools which are pragmatic enough to facilitate, where appropriate, their integration into legislation and regulation.

3. Optimisation

The optimisation of protection is one of the fundamental principles introduced by the ICRP to manage the risks associated with exposure to ionising radiation. It states that "the likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors" (Clement et al., 2021). Introduced since the earliest publications of the ICRP, the wording of this principle has evolved through various ICRP publications, developing the question of how far individual and collective exposures should be reduced. The wording "as low as reasonably achievable in view of the economic and social factors" was adopted in 1973 (ICRP, 1973).

ICRP Publication 101 provides an overview of the evolution of the optimisation principle and outlines the methodologies for protection of workers and the public (ICRP, 2006). However, there are still numerous questions raised for the practical implementation of this principle across all exposure situations and more particularly in the context of protection of the public and the environment.

Key issues

One of the key issues is to ensure there is shared understanding that optimisation does not always result in minimisation (of radiation dose). To achieve this, it is essential that the "reasonableness character" be considered within the optimisation process (IRPA, 2021; NEA, 2021b). The key question of "When is optimisation achieved?" still needs some guidance, which is adapted to various exposure situations. For instance, a common understanding among all stakeholders involved in the optimisation process is needed on how the factors to be considered in the optimisation process are chosen and balanced, and how to determine when optimisation is achieved and how this is evaluated.

The optimised decision-making process needs to include the management of radiological risks within a holistic approach (NEA, 2019 and NEA, 2021b). Greater consideration of all-hazards would help to achieve overall optimisation, not just protection from radiological risks. According to the situation, non-radiological factors to be taken into account need to be made explicit: ethical, societal, psychological, environmental, economic, etc. Guidance related to their identification and examples of the ways to consider them in the decision-making process could be useful. This also needs to address the associated physical and chemical risks. Depending on the circumstances, the physical and chemical risks can often be the dominant ones when compared to the radiological risks. Sustainability and ecosystem services are cross-cutting issues that need to be considered within a holistic optimisation process to reduce the potential impact, along with perceived risk, which can create significant societal impacts if not addressed correctly. The role and place of stakeholder involvement in these processes also need to be further explored (NEA, 2021a). The expansion and identification of the stakeholders involved is key to reaching reasonable levels of protection as well as to considering radiological protection in a holistic manner. The role of different stakeholders in making decisions should also be discussed further.

Medical exposures account for a large proportion of public exposure to radiation, making optimisation of great importance in this field. New technologies are being designed and brought to market to increase the quality of diagnostic imaging. This needs to be supported by and balanced against an RP system that aims to keep doses as low as reasonably achievable while maintaining an adequate level of imaging quality. Task Group (TG) 108 of the ICRP suggests evolving technical optimisation features and quality management systems will enable an extension of the optimisation process to individual patients and procedures based on clinical indication[4] .

Problems/challenges encountered

The role optimisation now plays in radiological protection is largely a process of reducing or maintaining exposures as low as reasonably achievable (ALARA), taking into account economic and societal factors, notably through the development of a radiological protection culture within the wider safety culture. However, there remains a need to further develop and integrate radiological protection culture alongside other fields in a holistic approach to optimisation. The regulation of radioactive waste and controlled discharges, where the philosophy of environmental law often results in regulations enforcing the minimisation of releases of radioactive substances, is one example.

The implementation of the optimisation principle to guide decisions during emergency exposure situations is still a challenge. There is a need to balance economic, social, human health and well-being (including mental health and psychosocial issues) and environmental considerations against the rapid implementation of protective/remedial actions, together with input from stakeholders and communities (ICRP, 2020a). Learning from the Fukushima Daiichi nuclear power plant accident shows that there is a need to avoid protective actions that do more harm than good when social, environmental and economic factors are taken into account (NEA, 2021c). Applying reasonableness is particularly important in emergency exposures given the demands associated with a response effort, i.e. for the preservation of life. At the same time, there is also a need to consider and balance the longer-term consequences and impacts of protective actions applied during radiological and nuclear emergencies. This should be seen as a key part of optimised decision making that will aid in the transition to an existing exposure situation and longer-term recovery.

Implementing optimisation of radiological protection for members of the public in existing exposure situations relies upon the use and understanding of the reference level[5] in this process. Guidance should be provided on the practical use of the reference level as it is sometimes considered by the various stakeholders as a limit value not to be exceeded (for example in the management of contaminated sites,) or in other cases as a value (i.e. action level) below which there is no need for further optimisation (for example for radon exposure) (Schneider et al., 2017). Further explanation of how to apply a reference level in existing exposure situations, including post-accident situations, would be useful.

Although the shift towards a more holistic approach is welcome, it has to be recognised that the implementation of this in terms of risk management makes the practical application of the optimisation process more challenging as it inevitably calls for a wide range of types of competences, co-operation between different authorities and other stakeholder involvement. This relates to the underlying general remarks of the EGIR that any additional complexity in the system must be evidenced to justify its inclusion and must be supported by examples and clear guidance. The NEA has recently hosted several workshops which have explored the application of the optimisation process through case studies and discussion, such as “Optimisation: Rethinking the Art of Reasonable”, held in Lisbon,

4. See www.icrp.org/icrp_group.asp?id=103.

5. The reference level is defined in the ICRP Glossary (2019) as “The value of dose used to drive the optimisation process in existing and emergency exposure situations. The value of a reference level will be selected within the bands recommended by the Commission according to the prevailing circumstances. This selection should consider the actual individual dose distribution, with the objective of identifying those exposures that warrant specific attention and should be reduced as low as reasonably achievable.”

Portugal in January 2020 (NEA, 2021e), "Multifactor Optimisation of Predisposal Management of Radioactive Waste", held in Paris, France, in February 2020 (NEA 2021f), and the NEA/DSA workshop "Regulatory Framework of Decommissioning, Legacy Sites and Wastes from Recognition to Resolution: Building Optimisation into the Process", held in Tromsø, Norway, in October 2019 (Sneve, 2020). Also in planning is the forthcoming "3rd Stakeholder Involvement Workshop on Optimisation in Decision-Making" to be hosted by the NEA in 2023. These workshops provide further evidence on how a holistic optimisation process can be applied and where the ICRP review of the RP system can close some of the remaining gaps.

Addressing the key issues

As introduced in the RP system chapter (section 1), applying the fundamental principles in sequence can be challenging. It appears that in many cases the optimisation of protection is the key principle in managing radiological protection in exposure situations. The relationship between optimisation and the fundamental principles of justification and limitation could be better reflected in the presentation of the RP system.

It is important that evidence be collected to demonstrate how optimisation is currently applied in regulation and implemented in practice across various circumstances and sectors, for different categories of exposure and exposure situations, and to point out the commonalities and differences and whether it has been disproportionately applied. The review should take the opportunity to exchange experience between various sectors of activity and consider case studies related to actual and potential risks, including risks unrelated to nuclear or radiological emergencies, that were affected by uncertainties and often coupled with unpredictable outcomes [6]. A greater understanding of how the optimisation principle has been applied across various sectors would highlight whether it is disproportionately applied in one sector over another. The ICRP's review could also include an identification of the decision aiding methods used, for example the implementation of modern computational techniques. The review should also include the case of optimisation in emergency and existing exposures and the lessons learnt from large-scale nuclear accidents such as the Fukushima Daiichi nuclear power plant accident.

There is a need to ensure that reasonableness is applied within the optimisation process and to develop the shared understanding that optimisation does not always result in minimisation. Mechanisms to support the application of reasonableness, such as "the three R's of Reasonableness; Relationships, Rationale and Resources" (Wieder et al, 2022) within the optimisation process should be further integrated into the system, while considering the capability to transpose such mechanisms into regulatory frameworks. The outputs of the work initiated by the ICRP in the TG 114 on "Reasonableness and Tolerability in the System of Radiological Protection" will be a relevant input to identify those mechanisms, as is the consideration of a better integration of assessments of ecosystem services and the delivery of sustainable development within the optimisation process (see section 3).

It is agreed that the optimisation of protection should be multi-dimensional. The exploration of tools and methods that are available to consider radiological, chemical and other environmental and human health hazards in support of optimised decision making

6. This is very much in line with NEA publications No. 7305 (NEA, 2016) and 7419 (NEA, 2019) and also the on-going work of the NEA Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM) and the NEA Expert Group on a Holistic Process for Decision Making on Decommissioning and Management of Complex Sites (HDCS).

would help in drafting guidelines on holistic approaches. Evidence from the previously mentioned NEA workshops should be referred to in the review, along with the work of the CRPPH High-Level Group on Low Dose Research (HLG-LDR) on the human and environmental impacts of ionising radiation at low doses, the understanding of which is central to the optimisation process.

The optimisation process is particularly significant in medical exposure as no dose limits are recognised for patients. Therefore, in medical exposure the reasonable dose level to achieve the medical objective is related to the optimisation process, and a real and explicit incorporation of ethical basis with scientific knowledge would be helpful. It will be important to integrate and emphasise the work of TG 109 on Ethics in Radiological Protection for Medical Diagnostics and Treatment into the revised system in line with the Terms of Reference of TG 109, which notes "a clear understanding of ethical values together with the principles of radiological protection, can help address issues of potential conflict in decision making". [7]

7. See www.icrp.org/icrp_group.asp?id=104.

4. Environmental protection

Protection of the environment is one of the main objectives of the ICRP and is an area that has developed significantly in the RP system over the past two decades. Key advances in environmental protection have occurred since Publication 103, which therefore needs to be considered in conjunction with other companion publications. The core publication is Publication 108 (ICRP, 2008) while other publications document different parts of the approach to demonstrating protection of the environment, as follows:

- Publication 114 (ICRP, 2009) examines approaches used to model the transfer of radionuclides in the environment
- Publication 124 (ICRP, 2014) considers the application of environmental protection in planned, emergency and existing exposure situations
- Publication 136 (ICRP, 2017) improves and supersedes the Dose Coefficients (DCs) in ICRP 108
- Publication 148 (ICRP, 2021) recommends Relative Biological Effectiveness (RBE) values for Reference Animals and Plants (RAP).

Protection of the environment in the context of climate change and wider sustainable development is also a key part of continuous improvement of the RP system. This includes increasing links with the UN sustainable development goals through, for example, the newly created TG 125 on Ecosystem Services and exploring the radiological protection considerations of climate change mitigation and adaptation.

Key issues

The objective of environmental protection is defined in Publication 103 as "…preventing or reducing the frequency of deleterious radiation effects to a level where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities and ecosystems…" (ICRP, 2007). Publication 103 para 362 also states that "it has been considered that the standards of environmental control needed to protect the general public would ensure that other species are not put at risk, and the Commission continues to believe that this is likely to be the case" (ICRP, 2007). Such statements need to be reviewed to ensure the position remains fit for purpose and reflects current thinking on environmental protection.

In the ICRP publications specifically dedicated to the topic of environmental protection (i.e. Publication 108 and its companion publications listed above), Reference Animals and Plants (RAPs) are introduced and Derived Consideration Reference Levels (DCRLs) are presented, as well as how to use these concepts and dose criteria in the overall framework. Note that the latter has already been adopted by some countries in national regulations and oversight of the natural environment and wildlife. Even though the proposed approach, based on RAPs and DCRLs, is already used by some countries in a form of ecological risk assessments, there is a need to better integrate this framework into the RP system and provide more guidance for the consideration of governments and policy makers on how the RAPs and DCRLs should be used for the purpose of demonstration of protection/conservation of the environment from adverse effects of exposure to ionising radiation. Consideration of how to gain more widespread acceptance of the current approach to environmental protection, for example through the use of RAPs and DCRLs, is needed, given that only a limited number of countries have implemented Publication 108 and its companion publications. Any recommendations the ICRP makes need to be practical and implementable, and have broad understanding and support.

In the paper, "Keeping the ICRP recommendations fit for purpose" (Clement et al., 2021), the field of environmental protection was somewhat extended by naming it protection of the environment and non-human biota. In addition to wild flora and fauna, non-human biota also includes domesticated species and veterinary patients. In order to be able to formulate relevant recommendations and apply these in practice, there is a clear need for better definitions of these different terms and related areas.

There has been an increased interest in and focus on environmental protection since Publication 103 and Publication 108 with increasing concerns over issues such as the consequences of climate change and pollution. The ICRP should further develop the objective on environmental protection and align this with other global goals, such as the UN sustainable development goals. In order to address these, there is, as previously shown by the NEA in the report "Scientific Issues and Emerging Challenges for Radiological Protection", a need to be able to describe and quantify the effect of ionising radiation on the environment, the latter being defined as non-human species and their related ecosystems (NEA, 2007).

Problems/challenges encountered

Publication 108 (ICRP, 2008) and Publication 124 (ICRP, 2014) contain some guidance and recommendations on environmental protection that support policymaking. However, there are still gaps that need to be addressed in these recommendations, primarily regarding integration into the overall RP system. This includes, for example, how to apply in regulation and implement in practice the principles of radiological protection for each exposure situation, including protection of the environment during emergencies. To do so there is a need to clearly define the scope of environmental protection in order to be able to assess in a transparent and science-based approach the radiation-induced health risk for non-human species (and their various levels of ecological organisations – individual, population, community, ecosystem) as this constitutes the basic information to formulate and support effective protection strategies. The need to address the protection of the natural environment and wildlife in terms of species and populations on the one hand, and protection of domesticated animals alongside veterinary patients on an individual animal level on the other hand, cannot be addressed in the same strategy. These two different perspectives have to be separated in any future recommendations and while doing so there is a need to demonstrate why it is reasonable from an ethical perspective to distinguish between these two cases. The forthcoming ICRP Publication on "Radiological protection in veterinary practice" addresses this issue (ICRP, 2022).

Environmental protection is a key part of the UN sustainable development goals. To address the goals from a radiological protection point of view, the RAPs and DCRLs will not fully suffice. More guidance is needed on how to integrate environmental radiological protection into the overall RP system in the different exposure situations. This will need to address how the RAPS, and particularly DCRLs, should be used and interpreted. Clement et al. (section 2.7, 2021) suggests that a new category of exposure may be required (non-human biota). To implement environmental radiological protection, any system must look at the whole ecosystem and not just focus on a single species or group of species as the one represented by RAPs (defined at the taxonomic level of family). These limitations are concurrently under examination by two ongoing ICRP Task Groups. The first, TG 99, develops methods and underlying data to support a broader biodiversity representativeness of RAPs to the class and upper taxonomic levels and transparently makes it possible to semi-quantify uncertainties related to DCRLs (the latter being updated by the most recent data and justified assumptions). The second Task Group, TG 105 will, on these bases and through case studies, issue recommendations for the application in any demonstration of protection of both humans and the environment. Consideration should also be given as to whether and how optimisation[8] should take into account the environmental impact of radiation. To fully address the sustainable development goals, ecosystem services have to be addressed somehow, as highlighted in Clement et al (2021). This is the topic of a newly established Task Group, TG 125.

Regarding the application of the approach, the current method making use of RAPs and DCRLs is well-grounded in the state of the art and easy to implement for planned exposure situations and, to a lesser extent, to existing exposure situations. However, it suffers from limitations in emergencies due to the inadequacy of the equilibrium approach for dosimetric assessment, and as a consequence of risk estimates.

Addressing the key issues

It is strongly recommended that the ICRP separate the discussion on non-human biota into two categories. The first is the environmental protection of the natural environment and wildlife. The second is protection of domesticated species and veterinary patients, which could be supported by guidance for the application of ionising radiation and radioactive substances in veterinary medicine, which also considers the exposure of the persons involved. It would be helpful to have a clearly stated umbrella objective, as was done in Publication 103 ("preventing or reducing the frequency of deleterious radiation effects to a level where they would not impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities and ecosystems") (ICRP, 2007). This could be updated by highlighting the UN sustainable development goals and concepts such as ecosystem services.

For the first category on protection of the natural environment and wildlife, Publication 108 (ICRP, 2008) and Publication 124 (ICRP, 2014) are a good starting point for integrating this into the RP system. There is more work needed to also be able to address ecosystem services and it is not obvious how that could be done. For that reason, the ICRP initiative to establish TG 125 is welcome. This Task Group will provide background and general recommendations on whether and how ecosystem services can support a holistic approach to environmental radiological protection and explore how the RP system contributes to the delivery of sustainable development.

However, hazard analysis with regard to ecosystem services is not only an issue for radiological protection; several of the issues which need to be addressed are also present in other fields, such as the regulation of chemical substances. A broader approach taking inspiration from these fields could be fruitful in both addressing ecosystem services and integrating protection of the environment fully into the RP system.

The approaches and underlying concepts, methods and tools should clearly make it possible to demonstrate protection of the environment for the three types of exposure situations.

8. Optimisation is defined in ICRP Publication 103 (2007) as "The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, as low as reasonably achievable with economic, societal and environmental factors being taken into account."

5. Radiation detriment and risk

Radiation detriment is a multi-dimensional concept developed by the ICRP to quantify the harmful stochastic effects of radiation exposures at low doses or low dose rates on human health, for the purposes of radiological protection (Clement et al., 2021). To date, only cancer and hereditary effects are considered (ICRP, 2007). In ICRP Publication 103, radiation detriment is obtained by combining nominal risk calculations with assessments of lethality and reductions in length and quality of life resulting from the occurrence of the pathology, using available data and scientific knowledge. This is a complex and multi-step calculation with several inputs that are averaged or otherwise "binned" into a limited number of categories. These calculations assume a linear dose-response relationship for solid cancers with no threshold and include a dose and dose rate effectiveness factor (DDREF) of two[9]. Tissue-specific detriment values are defined for several cancer sites and tissues, and then summed to arrive at a value for total radiological detriment. One value of radiological detriment has been defined for the general population and another for workers. Tissue-specific detriment values are used to determine the weighting factors for tissues and organs to enable the calculation of effective dose.

Key issues

The ICRP's proposal to reassess the current estimates of detriment using updated data sets and the latest scientific findings is welcome (including reassessment of cancer base rate and factors for lethality, loss of quality of life and number of years, due to improved cancer treatment). Areas of focus should include revisiting and achieving consensus on the appropriate value for the DDREF (if any), and revisiting tissue weighting factors to ensure that they reflect new knowledge. There should also be more discussion on how the detriment parameters "lethality factors, loss of quality of life and number of years" are considered in the calculation of detriment.

Detriment values have been calculated only for cancer and hereditary effects, with cancer dominating the assessed value for total detriment. Hereditary effects are included despite a lack of evidence in humans because an effect is suspected based on animal studies. The EGIR supports the ICRP proposal to review the validity of assumptions about heritable effects, as well as to consider inclusion of other suspected or recognised non-cancer outcomes such as circulatory diseases and eye lens opacities. Neuronal and cognitive effects may also merit consideration in some settings (Pazzaglia et al, 2020; Pasqual et al, 2021). It is further recommended that a summary of this review explaining the rationale for including or excluding health outcomes in detriment calculations be elaborated in the updated guidance. To this end, the EGIR also supports the review of the health effects classification currently being undertaken by TG 123 on Classification of Harmful Radiation-induced Effects on Human Health for Radiological Protection Purposes.

As suggested by the ICRP, there is a need to review the assessment of radiation detriment by taking into account the age and sex-dependence of radiation sensitivity, and potentially differentiating the tissue weighting factors according to sex and age groups. The idea of no longer referring the effective dose for a hypothetical reference person only, but separately for different groups (depending on age, sex or other characteristics) means that dosimetric

9. The methodology behind the current estimates of detriment as well as thoughts on its evolution are currently under review by ICRP Task Group 102 (public consultation completed in June, 2020).

and radiological protection-relevant quantities would be assessed in a way that is as scientifically correct as possible, making optimal use of information that is already available and improving transparency.

In addition, there is room for further clarifying the concept and appropriate use of detriment and detriment-adjusted risks (for example, use of the values identified in Publication 103, Table 1) and elaborating its relationship to other key elements of radiological protection, such as effective dose.

Problems/challenges encountered

While there is general support for recalculating estimates of detriment using more detailed and updated data, there are concerns that the application could lead to unnecessary practical and/or ethical challenges. Getting several values for effective dose, depending on the gender and the age of exposure, could lead to confusion, inconsistent application and inadvertent inequity (ICRP, 2018). For example, more detailed calculations would make explicit that dose limits could be higher for a 50-year-old man than for a 25-year-old woman and there is a risk that this could lead to a perception that different limits are required for each, or to discriminatory hiring practices.

Furthermore, Publication 103 says that "The aggregation of very low individual doses over extended time period is inappropriate, and in particular, the calculation of the number of cancer deaths based on collective effective doses from trivial individual doses should be avoided" (ICRP, 2007). However, the meaning of "trivial" is not quantified or illustrated by the ICRP and therefore needs to be explained. It is also important to ensure that the benefits and original intent of using collective doses are not lost.

Addressing the key areas of improvement

The ICRP has made good initial progress towards clarifying the concept of detriment and proposing directions for its evolution in Publication 152 on the methodology for radiation detriment calculation (ICRP, 2022). Many of the proposals for evolving the calculation of detriment that are identified in Sections 4, 5 and 6 of the ICRP Publication address issues identified by the EGIR (ICRP, 2022).

The approach of assessing exposure and risk as scientifically as possible, considering the dependence of detriment and dose on age, sex or other characteristics, is welcome specifically when considering higher doses. This needs to be balanced against the regulatory application, practical implementation and ethical considerations, and the reasons for not including such an approach within Publication 103 need to be revisited to ensure it results in a clear net benefit for stakeholders. At these levels, growing evidence for increased risk of circulatory diseases or eye lens opacity merits consideration in the assessment of detriment, as well as for neuronal and cognitive effects at doses which can be reached or exceeded during some interventional procedures in medicine and computed tomography (CT) perfusion examinations. References to epidemiological studies should be increased as part of the review (notably needed for risk coefficients), with appropriate attention to documented concerns about uncertainties in dosimetry (NEA, 2021d). The work of TG 121 on the Effects of Ionising Radiation Exposure in Offspring and Next Generations, TG 122 on the Update of Detriment Calculation for Cancer, and TG 123 on the Classification of Harmful Radiation-induced Effects on Human Health for Radiological Protection Purposes will help to tackle a number of issues raised in this report associated with the concept of radiological detriment and risk.

It is important not to introduce unnecessary complexity. If the ICRP revises its assessments of detriment and risk because of further developments in the state of the art in science and technology, or to address lessons learnt from 15 years' experience using Publication 103, the added value for radiological protection should be documented in a comprehensible manner and the benefits/impacts clearly described. Furthermore, clear direction must be provided to support the interpretation and use of detriment and detriment-adjusted risk by professional and non-professional audiences. For example, it could be discussed as a more refined concept, such as by including more parameters and more differentiated weighting factors, for some audiences and purposes, as well as a broader concept that is easier to understand and apply.

Finally, exploring new ways to assess detriment should not be discounted as it is important to find intuitive ways of describing and thinking about the concept. For example, methods such as those using the disability adjusted life year (DALY) or quality adjusted life year (QALY) may better capture effects on quality of life and could improve communication with the end users.

6. Exposure situations

The notion of "types of exposure situations" is one of the key concepts in the ICRP system of radiological protection. The ICRP general recommendations have evolved from the process-based protection approach using practices and interventions in Publication 60 (ICRP, 1991) by moving to the situation-based protection approach using planned, emergency and existing exposure situations in Publication 103 (ICRP, 2007).

Key issues

Although the evolution to the concept of exposure situations has been beneficial, it has been sometimes difficult to apply and, as a result, has not been implemented in many countries. At the forefront is the need for further clarity and guidance on the application of the fundamental principle of optimisation in each exposure situation. Experience has also revealed a need for further guidance on the definitions and interpretations of the types of exposure situations, the transition between exposure situations and the application of the concepts of limits, constraints and reference levels.

Problems/challenges encountered

Challenges remain in dealing effectively with sources that are present in the environment, such as cosmic radiation, radon, concentration of naturally occurring radioactive materials by industrial processes, as well as the radioactive materials released following a radiological or nuclear emergency. There are cases where the exposure to these sources is considered as an existing exposure situation; however, the approach used to control exposure may be comparable to those for planned exposure situations. When considering radiological protection for a given situation, the important thing is to do the best one can in the prevailing circumstance (i.e. optimisation). However, if it is only focused on the classification of the exposure situation and numerical values, it may not result in the best approach.

Other challenges related to exposure situations include the transition from an emergency exposure situation to an existing exposure situation, following a radiological or nuclear emergency, and how the longer-term recovery should be managed as an existing exposure[10]. This includes ensuring that preparedness for recovery is appropriately addressed by reflecting the recommendations raised in Publication 146 (ICRP, 2020) and more guidance is provided on the transition between exposure situations. Using terminology that is better understood by the wider emergency response and recovery community outside of radiological protection is important, i.e. clearly explaining how an existing exposure situation relates to the recovery phase of an emergency. Further to this, the dose criteria of limits, constraints and reference levels require a thorough examination and clarification of the distinction between these terms. This is also especially important in emergency exposure situations, where reference values are often equated with limits. Further efforts are needed to provide clearer recommendations for the selection, establishment and communication of limits, constraints and reference levels. A holistic review of these concepts is needed, especially with consideration of the communication of these concepts with stakeholders and of the practicalities of implementing these concepts

10. With links to ICRP Publication 146 (ICRP, 2020a) and the associated recommendations for post-accident recovery management.

across all exposure situations. This is particularly true when terms may have different meanings and uses in different contexts.

"Categories of exposures" is an equally important concept in the ICRP system of radiological protection. There are still challenges related to the definition of occupational exposure and the appropriate protection of workers in each of the three exposure situations and in particular in existing exposure situations. The application of the relevant protection principles for the categories of exposure (currently defined as workers, public, patients) in the different types of exposure situations is not always straightforward. The need to define new categories might also need to be explored to better correspond to some situations, noting that it is important to not further complicate the RP system. In particular, as there is a clear willingness to integrate the protection of the environment in the whole system, some guidance is needed on the way to consider the non-human biota in each exposure situation (see section 3).

As currently written in Publication 103, existing exposures cannot in theory revert to planned exposures. This could mislead directly affected stakeholders into believing that, having been negatively impacted, they will always be negatively impacted and that their future situation cannot be improved by planned actions to return to normality. This also unnecessarily complicates the communication process and stigmatises those affected. It could be particularly useful to clarify this for the purposes of post-accident recovery and the removal of restrictions/long-term protective actions.

Addressing the key issues

To effectively promote discussions on the development of the next general recommendations, it is necessary to analyse whether the introduction of the exposure situations in ICRP Publication 103 has triggered any concrete improvements over the 15 years or more, and in what areas it has not done so.

Taking the existing exposure situation as an example, about half of the IAEA member states have established a regulatory framework for existing exposure, while the other half have not yet done so (as reported at the 50th meeting of IAEA RASSC, June 2021). For countries that have not yet adopted the situation-based protection approach, it would be beneficial to share the experiences of countries that have already adopted it.

The practical implementation of the new regulations for those countries that have adopted the new framework could be evaluated on the basis of specific case studies, selected in areas where issues are raised, such as workers in existing exposure situations, the use of reference levels for the management of existing exposure, the management of contaminated areas due to past practices and post-accident situations, and the consideration of the protection of the environment in optimisation processes applied to the release of installations. The results of these case studies would help to better understand where the issues are and provide elements to solve them.

It is noted that the ICRP is working on reviewing the concept of exposure situations through the creation of a dedicated TG (TG127). This TG will explore many of the issues discussed in this chapter. The continuation of such efforts will further highlight successes and challenges related to exposure situations and contribute to the consideration of improvements in the next general recommendations.

7. Other issues

In addition to the five themes prioritised for review by the EGIR, there were also a range of other issues identified by EGIR members that will need to be considered. This section briefly introduces these additional issues, including those highlighted by the CRPPH shown in Appendix A, as they are likely to be considered by the EGIR as part of the longer-term review.

Firstly, stakeholder engagement, public communications and ethical considerations are key topics which are cross-cutting to the themes prioritised by the EGIR. These have not been treated as standalone issues, but rather incorporated under each section, for example the involvement of stakeholders in optimised decision making. Simplification of the RP system, which is encouraged by both the EGIR and CRPPH, will facilitate stakeholder engagement and public communications and make it a system that is focused on the needs of people rather than the needs of scientists and experts. Education and training should also be seen as an important part of this and built into the implementation of the revised system. The outputs from the NEA's 3rd Stakeholder Engagement Workshop on Optimisation in Decision-Making and preceding webinars, due to take place throughout 2023, will provide valuable recommendations and evidence to inform parts of the review of the RP system.

With regards to ethical considerations, the system would benefit from further explanation in terms of the practical application across the fundamental principles, including how to balance individual risks against societal risks. It will be important that ethical values be treated as a core component of the fundamental principles and not dealt with as a separate layer.

In its preliminary findings, the CRPPH raised the need to advance research in the low-dose and low-dose rate health risk area and incorporate this within the review by linking in with NEA's High-Level Group on Low-Dose Research (HLG-LDR). Reducing the uncertainties with regards to low-dose (low-dose rate) exposure and related health risk will continue to improve the system and increase transparency. This will ultimately lead to more robust decisions that stand up to challenge. Low-dose research is addressed under the theme "Radiation detriment and risk". Other areas raised by the CRPPH will also be addressed under the current proposed themes. This includes issues such as learning from other high hazard sectors, encouraging an all-hazards approach for emergency preparedness, response and recovery (NEA, 2022b), reviewing occupational exposures to nuclear facility workers, and updating the protection objectives of the system in terms of greater recognition of environmental protection, moving from a purely radiological protection approach (e.g. protection of human health and the environment against deleterious effects of exposure to ionising radiation) to an integrated and holistic approach, and advanced preparedness for how to apply the RP system to radiological and nuclear emergencies and post-accident existing exposure situations.

8. Conclusion

The initial views presented in this report are a reflection of the early appraisal by CRPPH and EGIR members on the review and revision of the ICRP system of radiological protection. This has mainly been focused on reviewing the ICRP paper "Keeping the ICRP Recommendations fit for purpose" (Clement et al., 2021) but also draws upon the EGIR members' individual/professional experiences of using the current RP system in practice and a review of supporting ICRP and NEA publications. The key message to be taken from the EGIR's initial review is that members feel that any changes to the system should be seen as an exercise in continuous improvement rather than a significant overhaul. The EGIR also welcomes the proposed review process adopted by the ICRP and the openness and transparency being promoted.

The EGIR has focused its initial review on five themes: the system of radiological protection, optimisation, environmental protection, radiological detriment and risk and exposure situations. The key issues, problems and challenges encountered and recommendations for addressing the key issues are presented against each. An essential part of the review and revision of the RP system will be to assemble vital evidence to justify any proposed changes. This will need to be supported by a thorough investigation of how the current system documented in Publication 103 and its companion publications has been applied in practice and how any changes to this will generate net benefits for a range of stakeholders. The application of the fundamental principles will be a key part of this review, notably around the sequencing of the principles, how optimisation is applied across each of the exposure situations and categories of exposure, and clearer guidance on how a holistic optimisation process can be achieved with consideration of the all-hazards approach.

The rapid development in environmental protection needs to be better reflected in the updated Publication 103, while noting the progress that has been made in subsequent publications. This also includes recognition of climate change adaptation and mitigation and greater consideration of sustainability with links to the UN sustainable development goals. In the context of environmental protection, the EGIR strongly recommends that the ICRP separate the discussion on non-human biota into two categories: (1) natural environment and wildlife, and (2) domesticated species and veterinary patients. The EGIR welcomes the review of how to calculate radiological detriment and risk; however, this needs to be considered in the broadest context to see whether the net benefits are achievable in practice. The introduction of the exposure situation approach in Publication 103 has been partly successful. To ensure this approach progresses and is better integrated globally, a thorough review with supporting guidance is needed, specifically for existing exposures and the transition between the three exposure situations. The EGIR also recognises the important role of cross-cutting issues, such as ethical values, stakeholder engagement and low-dose risk areas where uncertainties should be reduced. Such issues need to be considered in all parts of the review and revision of the RP system.

Further in-depth analysis and evaluation will be needed to investigate the themes and key issues raised in this report. The EGIR will review what areas require further work and make suggestions on a proposed work plan for consideration by the CRPPH. Any further research or activities, such as conducting workshops or surveys, will be intended to help the ICRP build the supporting evidence required to substantiate or challenge any proposed changes to the current system. The five themes prioritised in this report are sufficiently broad in scope to incorporate other issues as they arise throughout the review process, for example from feedback from key internal and external stakeholders.

The EGIR acknowledges and welcomes the progress that is being made by ongoing ICRP Task Groups in a number of the key issues discussed in this report. As part of the next steps, it will be important to monitor the outputs of such groups and assist wherever possible through the NEA’s well established links as an ICRP Special Liaison Organisation (SLO).

References

Clement, C., W. Rühm, J. Harrison, K. Applegate, D. Cool, C-M. Larsson, C. Cousins, J. Lochard, S. Bouffler, K. Cho, M. Kai, D. Laurier, S. Liu and S. Romanov (2021), "Keeping the ICRP recommendations fit for purpose", *Journal of Radiological Protection*, Vol. 41, 1390, https://iopscience.iop.org/article/10.1088/1361-6498/ac1611/pdf.

ICRP (2022), *Radiation Detriment Calculation Methodology*, ICRP Publication 152, Ann. ICRP 51(3), Sage Publications, Thousand Oaks, www.icrp.org/publication.asp?id=ICRP%20Publication%20152.

ICRP (2021), *Radiation weighting for Reference Animals and Plants*, ICRP Publication 148, Ann. ICRP 50 (2), Sage Publications, Thousand Oaks, www.icrp.org/publication.asp?id=ICRP%20Publication%20148.

ICRP (2020a), *Radiological protection of people and the environment in the event of a large nuclear accident*: update of ICRP Publications 109 and 111, ICRP Publication 146, Ann. ICRP 49(4), Sage Publications, Thousand Oaks, https://journals.sagepub.com/doi/pdf/10.1177/ANIB_49_4.

ICRP (2020b), *Radiation detriment calculation methodology* [online] available from: www.icrp.org/consultation.asp?id=97173938-CB10-4965-837A-23A96FEDFEC4, forthcoming.

ICRP (2019), ICRP Glossary [online] available from: http://www.icrpaedia.org/ICRP_Glossary.

ICRP (2018), *Ethical foundations of the System of Radiological Protection*, ICRP Publication 138, Ann. ICRP 47(1), Sage Publications, Thousand Oaks, https://journals.sagepub.com/doi/pdf/10.1177/ANIB_47_1.

ICRP (2017), *Dose Coefficients for non-human biota environmentally exposed to radiation*, ICRP Publication 136, Ann. ICRP 46 (2), Sage Publications, Thousand Oaks, http://journals.sagepub.com/doi/pdf/10.1177/ANIB_46_2.

ICRP (2014), *Protection of the environment under different exposure situations*, ICRP Publication 124, Ann. ICRP 43 (1), Sage Publications, Thousand Oaks, http://journals.sagepub.com/doi/pdf/10.1177/ANIB_43_1.

ICRP (2009), *Environmental protection: transfer parameters for Reference Animals and Plants*, ICRP Publication 114, Ann. ICRP 39 (6), Elsevier, Amsterdam, http://journals.sagepub.com/doi/pdf/10.1177/ANIB_39_6.

ICRP (2008), *Environmental protection - the concept and use of Reference Animals and Plants*, ICRP Publication 108, Ann. ICRP 38 (4-6), Elsevier, Amsterdam, https://journals.sagepub.com/doi/pdf/10.1177/ANIB_38_4-6.

ICRP (2007), *The 2007 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 103, Ann. ICRP 37 (2-4), Elsevier, Amsterdam, http://journals.sagepub.com/doi/pdf/10.1177/ANIB_37_2-4.

ICRP (2006), *Assessing dose of the representative person for the purpose of the radiation protection of the public*, ICRP Publication 101a, Ann. ICRP 36 (3), Elsevier, Amsterdam, https://journals.sagepub.com/doi/pdf/10.1177/ANIB_36_3.

ICRP (1991), *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Ann. ICRP 21 (1-3), Pergamon Press, Oxford, http://journals.sagepub.com/doi/pdf/10.1177/ANIB_21_1-3.

ICRP (1973), *Implications of Commission recommendations that doses be kept as low as readily achievable*, ICRP Publication 22, Pergamon Press, Oxford, http://journals.sagepub.com/doi/pdf/10.1016/S0074-27407380004-2.

IRPA (2021), "IRPA perspective on 'reasonableness' in the optimisation of radiation protection", www.irpa.net/docs/IRPA%20Perspective.pdf.

Laurier, D., W. Rühm, F. Paquet, K. Applegate, D. Cool and C. Clement (2021), "Areas of research to support the system of radiological protection. Radiation and Environmental Biophysics", 60:519–530, https://hal.archives-ouvertes.fr/hal-03513511/document.

NEA (2022a), *The Strategic Plan of the Nuclear Energy Agency 2023-2028*, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_64036.

NEA (2022b), *Building a Framework for Post-Nuclear Accident Recovery Preparedness*, NEA Publication No. 7582, OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_69605.

NEA (2021a), Statement on the possible role of the NEA and its Committee on Radiological Protection and Public health in the review and revision of the system of radiological protection, NEA/CRPPH(2021)12. (not available to public)

NEA (2021b), Strategic direction, objectives and prioritisation of activities to guide the evolution of the committee's programmes of work for 2021-2022 and 2023-2028, NEA/CRPPH(2021)2. (not available to public)

NEA (2021c), *Fukushima Daiichi Nuclear Power Plant Accident, Ten Years On: Progress, Lessons and Challenges*, NEA Publication No. 7558, OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_56742.

NEA (2021d), "Regulatory Implementation of the Equivalent Dose Limit for the Lens of the Eye for Occupational Exposures", OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_66220.

NEA (2021e), "Optimisation: Rethinking the Art of Reasonable: Workshop Summary Report", OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_60901.

NEA (2021f), "Multifactor Optimisation of Predisposal Management of Radioactive Waste: Proceedings of the NEA Joint Workshop", OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_59828.

NEA (2019), *Challenges in Nuclear and Radiological Legacy Site Management – Towards a Common Regulatory Framework*, NEA Publication No. 7419, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_40359.

NEA (2017), *NEA Workshop on Stakeholder Involvement in Nuclear Decision Making*, NEA Publication No. 7302, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_15006.

NEA (2016), *Management of Radioactive Waste after a Nuclear Power Plant Accident*, NEA Publication No. 7305, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_15008.

NEA (2009), *The NEA Contribution to the Evolution of the International System of Radiological Protection*, NEA Publication No. 6440, OECD Publishing, Paris, https://www.oecd-nea.org/jcms/pl_14456.

NEA (2007), *Scientific Issues and Emerging Challenges for Radiological Protection*, NEA Publication No. 6167, OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_14180.

Pasqual, E., F. Boussin, D. Bazyka, A. Nordenskjold, M. Yamada, K. Ozasa, S. Pazzaglia, L. Roy, I. Thierry-Chef, F. de Vathaire, M-A. Benotmane, E. Cardis (2021), "Cognitive effects of low dose of ionizing radiation – Lessons learned and research gaps from epidemiological and biological studies", *Environment International*, February, Vol. 147, www.sciencedirect.com/science/article/pii/S1568786418302751/pdfft?md5=f9d26caede048d294ed19c60e1872ae7&pid=1-s2.0-S1568786418302751-main.pdf.

Pazzaglia, S., G. Briganti, M. Mancuso and A. Saran (2020), "Neurocognitive Decline Following Radiotherapy: Mechanisms and Therapeutic Implications", *Cancers (Basel)*, January, Vol. 8:12(1):146, www.ncbi.nlm.nih.gov/pmc/articles/PMC7017115/.

Schneider, T., J-F. Lecomte, C. Schieber, S. Andresz, V. Chambrette, B. Le Guen and L. Vaillant (2017), "Synthesis of reflections and conclusions of the SFRP-IRPA workshop on the reasonableness in the practical implementation of the ALARA principle", *Radioprotection* Vol. 52(4): pp. 259–263, www.radioprotection.org/articles/radiopro/pdf/2017/04/radiopro170051.pdf.

Sneve, M.K. (2020), "Regulatory Framework of Decommissioning, Legacy Sites and Wastes from Recognition to Resolution: Building Optimisation into the Process", Report of an International Workshop, Tromsø, 29 October-1 November 2019, DSA Report 2020:05, Østeras: Norwegian Radiation and Nuclear Safety Authority, 2020, https://iopscience.iop.org/journal/0952-4746/page/optimisation-of-the-management-and-regulatory-supervision-of-nuclear-decommissioning.

United Nations (2015), Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1, 41 p., https://sdgs.un.org/2030agenda.

Wieder, J.S., T. Schneider and N. Martinez (2022), "The three R's of reasonable in radiological protection: relationships, rationale, and resources", *Journal of Radiological Protection*, Vol. 42, No. 2, IOP Publishing, DOI 10.1088/1361-6498/ac563b.

Annex A: Extract from CRPPH paper "Potential preliminary changes suggested to improve the current System of Radiological Protection" (NEA, 2021a, pp. 5-7)

Based on feedback from the ongoing work of the CRPPH and the NEA, as well as comments received in the survey on the strategic direction of CRPPH members in the summer of 2020 (NEA, 2021a), the preliminary expectations of member countries are mainly related to the need to modernise radiological protection policy and practice, including a thorough review of areas where a stronger foundation is needed. The expected changes are listed below (this list is far from exhaustive):

- Scientific foundation of the system and its three fundamental principles:
  - The radiological protection (RP) policy deserves continuous updating according to scientific progress and should incorporate feedback from experience, as well as the evolution of societal concerns and public awareness. In this area, one of the main expectations is the need for a simplified, clear and more flexible system, combined with better communication/dialogue with stakeholders (towards co-operative decision-making with concerned stakeholders), in particular with regard to the three fundamental principles, namely justification, optimisation and dose limitation, their understanding and their application in the main areas (i.e. medical application – workers and patients, including "veterinary patients"; industrial application – workers, general public, environment; naturally occurring environmental exposure – general public, environment).
  - A related issue is to advance research in the low dose risk area, to better use the key results in policy making and to improve the way research findings and policies are communicated to stakeholders. Among other things, progress in reducing scientific uncertainties and controversies in the low dose (rate) risk in human health and the environment would make the system more robust. This area is essential to improve decision making, and will play an important part in modernising the optimisation process towards a more transparent and holistic approach allowing for a comparison of risks and benefits of different options to manage a given exposure situation. Focusing on inclusive and deliberative approaches to risk assessment and management would allow risk governance to be seen as a mutual learning process in which experts and decision-makers can also learn, as can any other category of relevant stakeholders.
  - Simplifying the system with clear and transparent assumptions, underlying primary data and methods used for data analysis would limit one of the main obstacles to harmonisation of policy, legislation, regulation and application between international organisations and between member countries, namely differences in the implementation of ICRP recommendations by member countries.
- Fundamental principles should explicitly include ethical concepts and their related core values:

  - Optimisation involves ethical concepts such as reasonableness (ALARA) and more indirectly tolerability, both of which call for respect for key core values (i.e. dignity/autonomy, beneficence/non-maleficence, justice, prudence). The system would gain clarity and robustness in thinking on how these ethical concepts and key values could be logically considered as a basis of the system, and embedded into the definition and implementation of the three fundamental principles, rather than just being presented as an extra layer, which could be confusingly perceived as optional or implicit.
  - Given the rapid progress of procedures and technologies in the medical field, or the emergence of new areas of interest such as health radiation risk management in space, the fundamental principles need to be re-examined.
- Radiation risk policy and governance deserve to be revised in a harmonious way taking into account existing good practice for other risks:
  - Learning from non-radiological hazards areas, as well as from the all-hazards approach is seen as a fruitful way forward. This would improve the definition and application of the three principles and methods used to derive numerical criteria (used to apply the principles). Simplification could be proposed based on a reflection on the need for limits, constraints and reference levels with regard to the three exposure situations.
  - As RP moves towards a more holistic approach (multiple, multi-dimensional, multidisciplinary hazards), there should be an even greater focus on understanding and meeting stakeholder expectations. Modernisation should also incorporate: how policy and practice are communicated to a wider audience (than strictly the RP-related one); how policy and practice could be simplified and made more operational; and how to integrate consideration of other policies and practices so that radiological protection is properly integrated into the wider decision-making process and not seen as a separate "add-on" process.
- Protection objectives of the system should be more holistic (and more consistent with those existing for other hazards):
  - Protection of the environment should be better integrated into the system, with a clear definition added in the protection objectives of the system as well as a justification of the differences from the protection of human health;
  - Radiological protection area is rapidly moving from a purely physical-scientific approach (e.g. protection of human health and the environment against deleterious effects of exposure to ionising radiation) to an integrated and holistic approach where social sciences and humanities, economics and consideration of societal evolution come into play. For example, the trend to integrate multiple aspects in decision-making should justify considering a review of the RP system with a more holistic definition of human health which is “well-being” as proposed and defined by WHO;
  - This would require the development of approaches and tools to advance decision-making on a global scale, assessing both multiple risks and benefits, with optimisation balancing all factors (i.e. human health and well-being, natural resources including biodiversity and ecosystem functioning, social, economic, cultural aspects). In fine, optimisation of protection will become optimisation of well-being of populations directly and indirectly affected by circumstances and by protective action decisions. This clearly highlights the

need to further develop the co-expertise approach with the aim of co-operative decision-making involving all those who are primarily impacted by the decisions to be taken.

- Advanced preparedness on how to integrate all aspects in nuclear or radiological emergencies and in existing exposure situations should integrate a better understanding of vulnerability and its variation among various groups and situations, and how to deal with it.
- Potentially adverse effects of protective measures on mental health and psychosocial aspects could be developed and integrated somewhere in the overall calculation of adverse effects, possibly inspired on radiation detriment, so that they are taken into account in decision making.

- Occupational exposure of nuclear facility workers
  - One of the key areas that implementers of ICRP Publication 103 are struggling with is the management of worker doses in existing exposure situations. A close connection with ISOE could help to solve these issues.