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Committee on Radiation Protection and Public Health

DISCUSSION ON IMPLEMENTATION OF International Commission on Radiological Protection RECOMMENDATIONS CONCERNING REFERENCE LEVELS AND OPTIMISATION

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English - Or. English

Radiological Protection

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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 friendly and economical use of nuclear energy for peaceful purposes, as well as

– 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 policy analyses in areas such as energy and sustainable development.

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The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

Foreword

Upon the completion and publication of Publication 103, "The 2007 Recommendations of the International Commission on Radiological Protection," issued 2007, and the revision to the International Atomic Energy Agency (IAEA) Basic Safety Standards (BSSs) in 2011, the Committee on Radiation Protection and Public Health (CRPPH) is focusing its efforts on the practical implementation of these new recommendations and standards in all exposure situations. Its focus includes implications and considerations of emerging radiation protection issues and discussions on good practice methods for radiation protection.

Based on the recent activities of the Working Party on Nuclear Emergency Matters (WPNEM) in regard to the International Nuclear Emergency Exercise (INEX) 3 follow up (decision making and guidance for countermeasures), the recently completed INEX 4 exercise, and the 2010 workshop on practices and experiences in stakeholder involvement for post nuclear emergency management, it has been suggested that the WPNEM could make a valuable contribution to this overall CRPPH objective in the area of emergency exposure situations. Additionally, the WPNEM's past involvement in the review of the International Commission on Radiological Protection (ICRP) guidance documents on emergency and existing exposure situations has placed the group in a good position to contribute relevant experience to this topic. As such, it was proposed that the WPNEM establish an expert group to investigate issues in, and approaches to, the implementation of new international recommendations for emergency exposure situations.

The CRPPH mandated the Expert Group on the Implementation of New International Recommendations for Emergency Exposure Situations (EGIRES) of the WPNEM to investigate issues in, and approaches to, the implementation of the new ICRP recommendations and the revised IAEA BSSs for emergency exposure situations, specifically nuclear/radiological emergencies, including accidents and consequence management for malicious acts.

The work of the EGIRES focuses on the new ICRP approach to (1) optimising protection strategies, (2) establishing reference levels and (3) including stakeholder input in these processes. This report provides emergency management authorities in the Nuclear Energy Agency's (NEA's) member countries with clear and concise information and recommendations on key issues, possible approaches, and a summary of experience for implementing the new ICRP recommendations and revised IAEA BSSs for emergency exposure situations and for transition to resultant existing exposure situations.

Acknowledgements

The EGIRES secretariat would like to thank the Group members for their contribution to this report and Mr Toshimitsu Homma for the preparation of Annex 2.

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List of Acronyms

CRPPH	Committee on Radiation Protection and Public Health
EGIRES	Expert Group on the Implementation of New International Recommendations for Emergency Exposure Situations
IAEA	International Atomic Energy Agency
IAEA BSSs	International Atomic Energy Agency Basic Safety Standards
ICRP	International Commission on Radiological Protection
INEX	International Nuclear Emergency Exercise
NEA	OECD Nuclear Energy Agency
WPNEM	Working Party on Nuclear Emergency Matters

The primarily aim of protective measures is to avoid deterministic effects and to reduce the risks of stochastic effects as low as reasonably achievable under the circumstances. However, it is more than this. It is the effort to achieve a remediated environment that enables people to live without any, or with only very limited, restrictions.

Executive Summary

International Commission on Radiological Protection (ICRP) Publication 103, "The 2007 Recommendations of the International Commission on Radiological Protection", issued in 2007, defines emergency exposure situations as unexpected situations that may require the implementation of urgent protective actions and perhaps longer term protective actions. The ICRP continues to recommend optimisation and the use of reference levels to ensure an adequate degree of protection in regard to exposure to ionising radiation in emergency exposure situations. Reference levels represent the level of dose or risk above which it is judged to be inappropriate to plan to allow exposures to occur and for which protective actions should therefore be planned and optimised. National authorities are responsible for establishing reference levels.

The Expert Group on the Implementation of New International Recommendations for Emergency Exposure Situations (EGIRES) performed a survey to analyse the established processes for optimisation of the protection strategy for emergency exposure situations and for practical implementation of the reference level concept in several member states of the Nuclear Energy Agency (NEA). The EGIRES collected information on several national optimisation strategy definitions, on optimisation of protection for different protective actions, and also on optimisation of urgent protective actions. In addition, national criteria for setting reference levels, their use, and relevant processes, including specific triggers and dosimetric quantities in setting reference levels, are focus points that the EGIRES also evaluated.

The analysis of national responses to this 2011 survey shows many differences in the interpretation and application of the established processes and suggests that most countries are still in the early stages of implementing these processes. Since 2011, national authorities have continued their study of the ICRP recommendations to incorporate them into national plans. The International Atomic Energy Agency (IAEA) has adopted the ICRP recommendations into its revised Basic Safety Standards (BSSs). In practice, the full implementation will take some time. The EGIRES undertook this work to produce a report that would hopefully contribute to the common understanding of these important concepts and that would therefore assist in the use of reference levels and optimisation in the development of protection strategies in national plans.

This report provides emergency management authorities in the NEA's member countries with clear and concise information and recommendations on key issues, possible approaches, and a summary of experience for implementing the new ICRP recommendations and revised BSSs for emergency exposure situations and for resultant existing exposure situations.

I. Introduction and Scope

In the past, most emphasis in planning for, and response to, an emergency exposure situation has been placed on selecting protective actions in the early phase of an emergency to keep the doses to levels at which severe deterministic effects can be excluded and/or at which the risk of stochastic effects in the population is considered "acceptable". Less emphasis has been placed on the development of comprehensive protection strategies, which include considerations of the consequences of all exposure pathways and all phases (e.g., long-term rehabilitation). International Commission on Radiological Protection (ICRP) Publication 103, "The 2007 Recommendations of the International Commission on Radiological Protection," issued 2007, proposes a coherent conceptual framework for radiological protection in all types of exposure situations, including "emergency exposure situations" and "existing exposure situations". An emergency exposure situation is one that arises as a result of an accident, a malicious act, or any other unexpected event, and such a situation requires prompt action in order to avoid or reduce adverse consequences to, workers, first responders, emergency workers, and the public. The existing exposure situation is a condition that already exists when a decision on control has to be taken. Examples of existing exposure situations include exposure to natural background radiation and contamination from a nuclear or radiological emergency after the emergency has been declared to be ended.

ICRP Publication 103 reenforces the principle of optimisation of protection, which should apply in a similar way to all exposure situations. To assist in the process of "optimisation", the ICRP introduced the concept of a "reference level" to be used in conjunction with emergency and existing exposure situations. (Note that for planned exposure situations this concept is called a "dose constraint".) The emphasis on dose constraints and reference levels in Publication 103 has generated many questions and uncertainties. Subsequent publications further discuss the concept of optimisation and reference levels. These publications do not provide specific direction for the actual development of reference levels or on the implementation of optimisation; however, they do encourage interpretation by implementing authorities. With this perspective, the Expert Group on the Implementation of New International Recommendations for Emergency Exposure Situations (EGIRES) conducted a survey to explore the national experiences and to identify issues related to implementation.

The EGIRES survey results suggest that implementing the recommendations of ICRP Publication 103 in the development of national plans has been challenging. Current practices among nations show large variability in the interpretation and use of reference levels and optimisation in emergency and existing exposure situations. This report includes discussions on strategies to implement these important concepts from the group's viewpoint.

Scope

The scope of this document investigates issues in, and approaches to, the implementation of the new ICRP recommendations and the revised International Atomic Energy Agency (IAEA) Basic Safety Standards (BSSs) for both emergency exposure situations and resultant existing exposure situations. The scope includes the application of optimisation of protection strategies, development of reference levels, and the inclusion of stakeholder involvement in this process.

II. Recommendations on Emergency Exposure Situation and Resultant Existing Exposure Situation

The ICRP has defined the following three types of exposure situations that are intended to cover the entire range of exposure circumstances.

(1) "Planned exposure situations" are situations that involve the planned introduction and operation of sources. (This report will not discuss this exposure situation.)

(2) "Emergency exposure situations" are situations that arise as a result of an accident or result from a malicious act or any other unexpected event and that require prompt action to avoid or reduce adverse consequences. Emergency exposure situations require an adequate level of emergency preparedness and emergency response.[1]

(3) "Existing exposure situations" are situations that already exist when radiological protection decisions are necessary (e.g., situations that remain after the emergency exposure situation has been declared ended. (The context of this report will address this type of exposure situation somewhat; however, emergency exposure situations are the focus of this report.)

A key principle of radiological protection is the "optimisation of protection," which is defined as follows:

The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should all be kept as low as [is] reasonably achievable, taking into account economic and societal factors.

ICRP Publication 103 states the following:

The Commission emphasizes the importance of justifying and optimising protection strategies for application in emergency exposure situations, the optimisation process being guided by reference levels. The possibility of multiple, independent, simultaneous, and time-varying exposure pathways make it important to focus on the overall exposures that may occur from all pathways when developing and implementing protective actions. As such, an overall protection strategy is necessary, generally including an assessment of the radiological situation and implementation of different protective actions. These actions vary with time, as the emergency exposure situation evolves, and with place, as the emergency exposure situation may affect distinct geographic areas differently.

1 IAEA safety requirements publication GS-R-2, "Preparedness and Response for a Nuclear or Radiological Emergency," issued 2002, establishes the requirements for an adequate level of preparedness and response for a nuclear or radiological emergency. These safety requirements are under revision to consider, among other things, the ICRP's new recommendations, the lessons learned from the application of GS-R-2 since its publication, and lessons learned from response to the emergencies in the past 10 years.

ICRP Publication 103 defines "reference levels" as follows:

In emergency or existing controllable exposure situations, this represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration.

Furthermore, General Safety Requirement Part 3, "Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards," Interim Edition, issued November 2011 (IAEA BSSs), restates the Safety Fundamental (SF) Principle 9 [2] that arrangements must be made for preparedness and response for a nuclear or radiological emergency. This publication defines the reference levels as "the level of dose or the level of risk above which it is judged to be inappropriate to plan to allow exposures to occur, and below which the optimisation of protection and safety is implemented" that must be used for optimisation of protection and safety in both an emergency exposure situation and an existing exposure situation.

Setting the reference levels for emergency exposure situations and existing exposure situations in the revised IAEA BSSs is the required starting point in developing and optimising the respective protection strategy. In emergency exposure situations, IAEA BSS describes generic criteria necessary for taking particular protective actions and other response actions on the basis of the outcome of the optimisation of the protection strategy. These generic criteria should be used to derive default operational criteria that are observable conditions/indicators, operational intervention levels, and emergency action levels for triggering the emergency response. These default operational criteria are subject to revision based on the prevailing conditions.[3]

III. Reference Levels

The purpose of radiation protection in general is twofold: (1) to prevent deterministic effects and (2) to lower the risk of stochastic effects. Application of the dual purpose of radiation protection for emergency and existing exposure situations requires establishing bounds on allowable exposure. In particular, special care must be taken to establish a "goal" above which exposures should not be planned as allowable and below which protection should be optimised. These "goals" are identified as the reference levels. Reference levels can be used to develop and implement both protective actions (e.g., sheltering and evacuation) and other response actions (e.g., providing information and making measurements) in emergency and existing exposure situations. Although protective actions should be preplanned, they must still be flexible to appropriately address the actual circumstances of the event.

2 IAEA Safety Standards Series, No. SF-1, "Fundamentals Safety Principles," issued November 2006, states the fundamental safety objective (i.e., to protect people and the environment from harmful effects of ionizing radiation) and the 10 associated safety principles and briefly describes their intent and purpose.

3 IAEA General Safety Guide 2, "Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency," issued May 2011, elaborates, in detail, on the generic criteria for protective actions and other response actions in a nuclear or radiological emergency and development of operational criteria for their implementation.

The reference level is the starting point for the optimisation of protection. Exposures should be moved or maintained below the reference level through the implementation of an optimised protection strategy. For existing exposure situations, establishing a reference level does not mean that continued mitigation actions are no longer necessary if exposures are below the reference level. Protection should always be optimised as long as such actions do more good than harm—no matter the level of dose. Because doses in emergency and existing exposure situations cannot be controlled a priori, some exposures may, in fact, exceed reference levels. The exceedance of these reference levels should never be viewed as an infraction; instead, reference levels should be considered benchmarks for protection strategies to approximately reduce all doses as low as is reasonably achievable.

Reference level doses depend on the circumstances of the exposure. In ICRP Publication 103, recommended reference levels range from 20 to 100 millisieverts (mSv), as acute or annual exposures, for emergency exposure situations, and 1 to 20 mSv annual exposures for existing exposure situations. These reference levels are expressed in residual doses.[4]

The possibility of multiple, independent, simultaneous, and time-varying exposure pathways exist, depending on the event. It is important to focus on the overall exposures that may occur from all pathways when developing reference levels and implementing and optimising protective strategies.

At the planning stage, a protection strategy that would not reduce residual doses below the reference levels[5] should not be considered appropriate. During the response, such as after the implementation of urgent protective actions, the residual dose distribution has to be assessed and compared to the predetermined reference level to determine the effectiveness of the protection strategies. The highest priority is to reduce doses above the reference level. There should be consideration of the application of optimised protective actions for all those exposed, even those whose exposures are predicted to be below the chosen reference level(s). The reference level provides a benchmark against which to compare what is known about the situation to the protection that the implemented actions afford.

The EGIRES survey reveals that 8 (of 11) of the respondents indicated that their national protection strategies use established reference levels. These reference levels varied widely among respondents from using typical annual and lifetime doses because of natural radiation to embracing the range of 20 to 100 mSv (urgent actions) or 1 to 20 mSv (longer term) as stated in ICRP Publication 103.

The process by which reference levels were developed was not elaborated. Some respondents indicated that reference levels were used to determine the planning zones in which countermeasures should be prepared. Some respondents also indicated that reference levels were primarily used only in the planning phase; other respondents, however, stated that the primary use of reference levels was in the response phases.

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4 The projected dose is defined as the dose to be received should no protective actions be employed. The dose that would result when a protection strategy is implemented is called the residual dose. The dose that the implementation of the protective action would prevent is referred to as the averted dose.

5 The IAEA BSSs set the reference levels for both emergency and existing exposure situations in compliance with the ICRP Publication 103. The respective protection strategy to be developed and optimised based on these reference levels would have the goal to keep the residual doses as low as reasonably achievable below the reference level. For emergency exposure situation, the generic criteria introduced are compatible with this reference level and they are expressed in terms of projected dose and dose that has been received. Assessing the effectiveness of the protective actions and other response actions taken and comparison of the residual doses with the reference level in order to identify need for implementation of further protection strategies in an emergency exposure situation is also required by the IAEA BSS.

There was not a common application of reference levels among the respondents. No respondents reported the use of event-specific reference levels in their country. Specific responses to the survey are located in Annex 1 of this report.

IV. Protective Actions

In emergency and existing exposure situations, a protective action is an action taken to avoid or reduce doses that might otherwise be received. Protective actions necessarily will be different for different stages of an event, while the goal of dose reduction or avoidance remains the same. These actions are grouped together as a protective strategy and are subject to optimisation.

> *For emergency exposure situations, IAEA BSSs[6] provide a range of protective actions and other response actions that need to be taken to avoid or minimize severe deterministic effects or to reduce the risk of stochastic effects. These protective actions and other response actions are to be implemented individually or in combination in accordance with the generic criteria. These generic criteria and respective protective actions and other response actions to be taken in compliance with the generic criteria are based solely on consideration of radiation protection. Decision makers considering these criteria for taking protective actions and other response actions in response to a nuclear or radiological emergency should also consider other non-radiological factors (e.g., social, economic, environmental). However, precautionary urgent protective actions have to be taken under any circumstances when generic criteria for avoiding or minimizing severe deterministic effects are expected to be exceeded.*

There are many protective actions and combinations of protective actions to consider. To reduce exposures, the combined effect of the various actions will be taken into account. The choice of protective actions is also affected by their assumed duration. For example, a short-term evacuation carried out rapidly in combination with decontamination of the environment is likely a better choice than a temporary relocation for months, assuming the harm the evacuation causes and the decontamination are minor. Considerations other than radiological protection play an important role when taking long-term actions lasting several months or years; therefore, they require a thorough assessment of factors before the decision. Different factors affecting the choice of protective actions are presented in Figure 1.

6 Elaborated in IAEA Safety Guide No. GS-G-2.

Figure 1. Factors affecting the choice of protective actions (STUK)

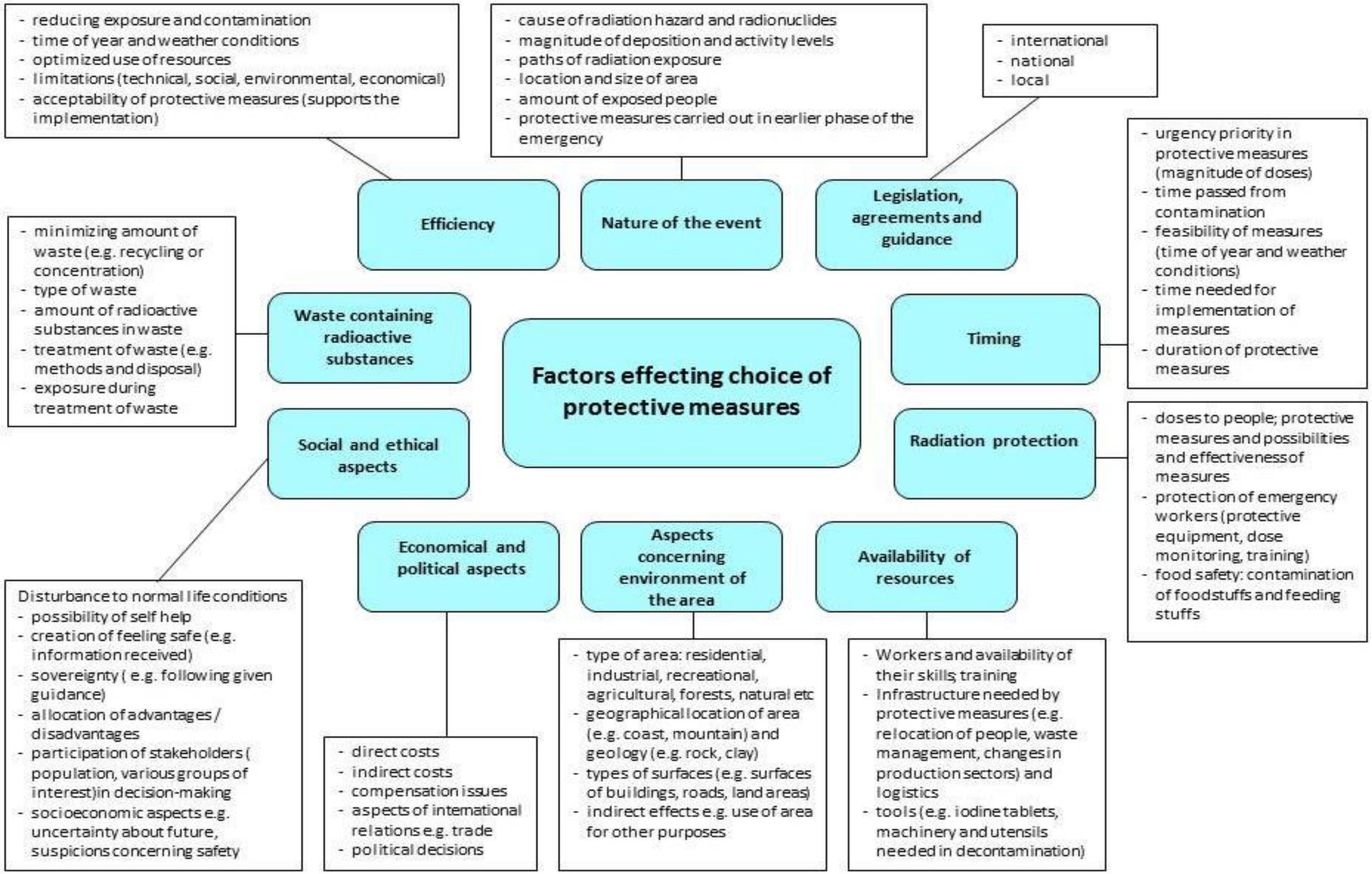
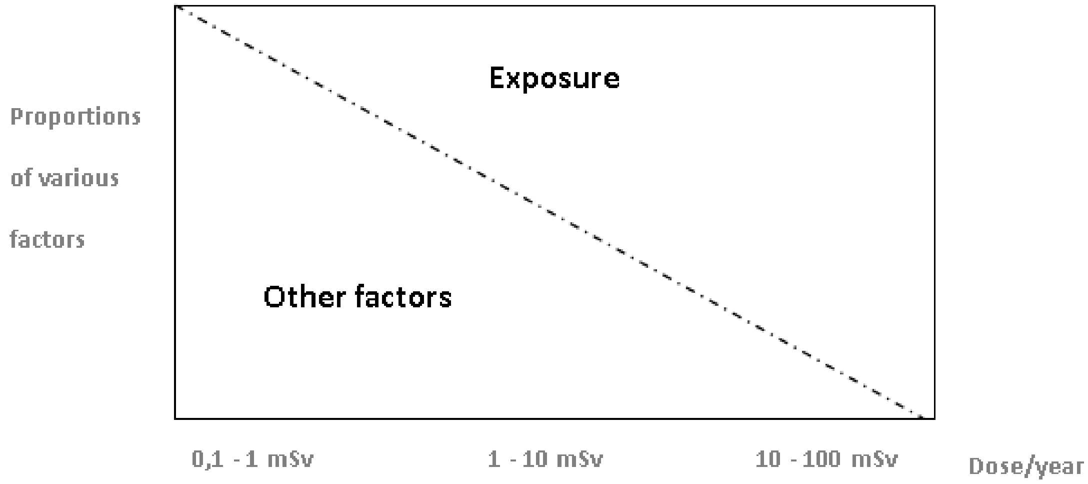


Figure 2 presents the significance of the exposure's magnitude in relation to other factors affecting decision making. These factors include ethical, social, environmental, and economical aspects. In a radiation situation in which the exposure is small, other factors may have more impact on decision making than the exposure itself. As the dose increases, it generally becomes the dominant factor in decision making. As the doses are reduced, other factors can assume greater importance.

Figure 2. The relative importance of the exposure in relation to other factors affecting decision making (STUK)



Protective actions and strategies for each phase of an emergency or an existing exposure situation can and should be optimised. In the planning process, overall optimisation strategies should be developed for each event phase. At the planning stage, it should be recognised that there will be greater uncertainty about the post-emergency phase than for the urgent response phase. As such, the strategies for existing exposure conditions are less detailed, whereas more detailed strategies for optimising urgent actions should be prepared.

Nevertheless, aspects of severe long-term implications of urgent protective measures (e.g., waste) should be considered in the planning phase. Analyses that will support development of the protection strategies are both quantitative and qualitative.

V. Optimisation

The establishment of reference levels can turn the focus to developing optimised protection strategies. Optimisation is a flexible, multi-attribute decision process that considers and evaluates many factors in development (preparedness) and implementation (response) of protective actions. Optimisation is always aimed at achieving the best level of protection under the existing conditions and circumstances through an ongoing, iterative process. This means that the level of protection should be the best under the prevailing circumstances, maximising the margin of benefit over harm. Optimisation of protection is not simply a minimisation of dose. Optimised protection is the result of an evaluation that carefully balances the detriment, if any, from the exposure, and all factors relevant to the wellbeing of individuals and society in general. Optimisation involves keeping exposures as low as reasonably achievable, taking into account practical, economic, and societal factors. The best option, therefore, is not necessarily the one with the lowest dose.

Optimisation is a common concept of many risk management programmes that address radionuclides and chemicals, although it is not always referred to as such. Optimisation analyses are quantitative and qualitative assessments applied at each stage of preparedness and response. The evaluation of these alternatives should take into account factors such as the following:

- radiation doses and health impact.
- exposure of sensitive populations (e.g., children, pregnant women).
- radionuclides footprint (types of radionuclides, deposition, and exposure pathways).
- types of contamination (chemical, biological, radiological, mixed hazards).
- areas affected (e.g., size, use of the area, location relative to population).
- other environmental hazards present.
- other human health risks of different strategies (e.g., potential casualties during evacuation).
- potential adverse impacts, including radiological and non-radiological to human health, the environment, the economy, and society overall.
- timeliness.
- analysis of actions already taken or planned and impact of future actions (short and long term).
- technical feasibility of the protection strategies.
- costs and resources needed to implement and maintain protective actions and remedial options.
- wastes to be generated or already generated and disposal options and costs.
- Desired or projected land uses.
- psychological and social effects to people and the society.
- self-help (measures taken by the population for themselves/society)
- public acceptability (must account for cultural sensitivities).
- preservation or destruction of places of historical, cultural, religious, national, or regional significance.
- possible effects on future generations.

Not all of these factors apply to all phases of a potential event, or to all events, but they can and should be addressed to some extent in the planning process. The system of optimisation is inherently judgemental. As such, it may not lend itself to inclusion in a regulatory scheme. However, the principles of optimisation and associated high-level processes should be included in a regulatory framework.

Two simplified examples of optimisation applied to protective actions are given as follows.

Example-1

In the "urgent" phase of emergency, where prompt actions are focused predominantly on protection of public health and safety. There are different ways this protection can be undertaken that would result in an optimised protection strategy. Predetermined staged evacuations of geographical areas are one example. In this instance, some of the population is evacuated in stages; those closest to the event would evacuate first based on plant conditions, followed by others further out from the emergency site event origin. This can substantially reduce radiation dose to the population while effectively using available transportation resources.

Example-2

The principles and strategies of optimisation apply to all types of emergencies that can result in the release radioactive materials to the environment. However some emergencies, such as transportation accidents, may only affect a relatively small or locali sed area. In such emergencies, it is likely easier to fully recover an area by actions such as removing topsoil or roadway surfaces or washing down roadways and buildings. In these types of emergencies, a plan for selecting reference levels and implementing optimised protection strategy may include complete recovery of the area.

It is possible for a contamination event to encompass a larger geographical area, but the resultant levels of contamination and dose are not significantly above background levels (e.g., fallout from a dirty bomb). In this type of emergency, the optimisation process, with its careful consideration of benefits and detriments, may result in a conclusion that no action may be a preferred option.

For large emergencies with the possibility of widespread contamination, such as nuclear power plant accidents or incidents, or the detonation of an improvised nuclear device, the development of a range of situation-appropriate criteria and strategies that could be used to further reduce or optimise exposure is an important part of emergency planning efforts. In developing situation-appropriate criteria, consideration must be given to the activities in the given area. For example, are there kindergartens or schools in the area? If such sensitive groups are present, it would be appropriate to plan more stringent criteria to ensure the doses are well below the reference level. In this case, the optimisation strategy could put more weight on dose reduction and less on other factors, as long as it is justified. Appropriate criteria and the resultant optimisation strategy for a location of limited occupancy, such as a forest, park area, or roadway, may place less emphasis on remediation and more emphasis on different restrictions concerning the use of the area. It is not unreasonable to expect that management of affected areas may take years to reach acceptable dose levels and living situations.

The EGIRES survey reveals that 4 (of 11) of the respondents stated that their countries had established a process for optimising the protection strategy for emergency and existing exposure situations. In a follow-up question on the interpretation of the definition of optimisation, the respondents provided a wide range of responses that suggests there are marked differences in how countries understand optimisation as part of the protection strategy. Responses to additional questions also showed this range of responses.

The demands of urgent response require pre-planned protective actions, which have been a part of the emergency planning safety culture for many years. Most emergency planning efforts have focused on urgent actions. As a result, these actions are well planned. Consideration of the timeline beyond the emergency response has not been well developed, however. The optimisation of protective actions as the emergency transitions into an intermediate or longer term phase is also very important. NEA survey respondents report that development of such strategies is under consideration for both urgent and longer term protection strategies. Detailed responses by country are located in Annex 1 to this report.

VI. Stakeholder Involvement

Even though decision making is the primary responsibility of decision makers and not stakeholders, the effective management of complex situations that an emergency creates requires the involvement of a broad range of stakeholders. Stakeholders are individuals or groups of people who have an interest in the outcome of an action, decision, strategy, or policy. Because stakeholders differ in the ways they are affected, the times at which they are affected, and the magnitude of the impacts, they can be divided into categories. It is important, therefore, not only to engage stakeholders but to address the concerns of each stakeholder group in developing both pre- and post-emergency plans.

The optimisation process provides decision makers an opportunity to develop acceptable solutions with the involvement of stakeholders. Stakeholder engagement is important in all phases of preparedness and in longer term recovery, particularly in the development of protection strategies. With stakeholder understanding and acceptance, the process of optimisation will be easier to implement.

Further discussion on the stakeholder involvement for emergency preparedness and response is found in the proceedings of the NEA workshop, "Practices and Experiences in Stakeholder Involvement for Post Nuclear Emergency Management," held from 12–14 October 2010, and hosted by the U.S. Nuclear Regulatory Commission. The workshop provided a forum for more than 70 experts representing organisations from 16 countries to:

- exchange information and experience on approaches to and issues in stakeholder involvement in post nuclear emergency management; and
- identify areas where enhancements in stakeholder involvement in post nuclear emergency management could be achieved nationally and internationally, and recommend approaches to address these areas.

The key collective views of the international experts participating at the workshop were the following:

- preparedness for stakeholder involvement should be a top priority;
- stakeholder involvement is not a goal in itself;
- radiation protection professionals are themselves stakeholders;
- it can be difficult for organisations to proactively work with stakeholders;
- use of existing networks and communication systems increases efficiency and enhances interactions;
- incentives for participation enhance stakeholder involvement;
- agreement on rules, procedures and processes is essential for effective stakeholder interactions;
- in some cases, skilled and experienced communications experts are needed;
- a broad spectrum of stakeholders is essential in emergency exercise planning;
- types of stakeholders and their roles will be different during different phases of emergency management, particularly during the recovery and rehabilitation phase;
- an all-hazards approach to emergency management is most efficient.

The workshop concluded with the expert participants identifying activities and recommended actions to advance stakeholder involvement, particularly in planning for post nuclear or radiological emergency management. A holistic, all-hazard, public health approach to emergency management was recommended, particularly in the planning, response, and conduct of the late-phase activities of recovery and rehabilitation. Because it will require a multidisciplinary team of professionals to deal with the spectrum of stakeholder issues resulting from a nuclear or radiological emergency, engaging stakeholders in developing a "Roles and Responsibilities" document for the different phases of emergency management will be essential. To establish long-term relationships based on trust, organisations should develop and conduct nuclear and radiological emergency exercises that include a wide range of stakeholders.

VII. Conclusions

Developing protection strategies starts with establishing reference levels relevant for the circumstances under consideration. These strategies are developed and optimised to ensure that residual doses will fall below selected reference levels. Optimisation emphasises the benefits and detriments to the entire exposed population and society, although it is unlikely that these benefits and detriments will be distributed evenly throughout society. As part of emergency planning efforts, it is important to develop a range of situation-appropriate criteria and strategies that could be used to further reduce or optimise exposure. The use of reference levels (as an upper bound) in conjunction with the optimisation process helps to balance potential unequal impacts of the optimisation process, ensuring that no individual(s) bears a substantially larger impact as part of the overall societal optimisation.

An important finding of the 2011 EGIRES survey suggests a broad common understanding of the ICRP's recommendations exists. The survey results show many differences in interpretation and application and suggest that most countries are still early in their implementation. Since 2011, national authorities have continued their study of the ICRP recommendations in order to incorporate them into national plans. The IAEA has adopted the ICRP recommendations into the revised BSSs. The full implementation will take some time.

The EGIRES undertook this work in the hope that its report would contribute to the common understanding of these important concepts and assist with the use of reference levels and optimisation in the development of protection strategies in national plans.

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ANNEX-1

Results of Survey on National Experiences

Introduction

ICRP Publication 103, "The 2007 Recommendations of the International Commission on Radiological Protection," issued in 2007, reenforces the principle of optimisation of protection, which should be applicable to all exposure situations. To assist in judging optimisation, the ICRP has extended its concept of dose constraints to be used in all exposure situations; this concept is called "reference level" in conjunction with emergency and existing exposure situations. The new emphasis on dose constraints and reference levels in Publication 103 has generated questions and confusion during the development of the new ICRP recommendations. It is thought that current practices show large variability in interpretation and use of reference levels in emergency exposure situations, mostly depending on national approaches.

The Committee on Radiation Protection and Public Health (CRPPH) charged the EGIRES with investigating issues in, and approaches to, the implementation of the new ICRP recommendations and revised BSSs for emergency exposure situations; specifically, nuclear/radiological emergencies including accidents and consequence management for malicious acts. This might include applying optimisation of protection strategies, setting reference levels, and including stakeholder input into this process.

As a first step, the expert group prepared the questionnaire below to investigate relevant approaches. Target audiences were regulatory authorities and national experts to express the collective opinion.

PART 1 "Optimisation of Protection"

"Optimisation of protection" in ICRP Publication 103 and IAEA BSS - Selected Quotations

ICRP Publication 103 states that "…The Commission emphasises the importance of justifying and optimising protection strategies for application in emergency exposure situations, the optimisation process being guided by reference levels. The possibility of multiple, independent, simultaneous, and time-varying exposure pathways makes it important to focus on the overall exposures that may occur from all pathways when developing and implementing protective measures. As such, an overall protection strategy is necessary, generally including an assessment of the radiological situation and implementation of different protective measures. These measures may well vary with time, as the emergency exposure situation evolves, and with place, as the emergency exposure situation may affect distinct geographic areas differently.''

IAEA BSS states that the optimisation of protection and safety, when applied to the exposure of workers, members of the public and careers and comforters of patients undergoing radiological procedures, is a process for ensuring that the magnitudes and likelihood of exposures and the numbers of individuals exposed are as low as reasonably achievable, taking economic, societal and environmental factors into account. This means that the level of protection would be the best under the prevailing circumstances. ''… "…Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.''

Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?

If No:

a) Why not?

If Yes:

b) How do you define optimisation strategy as it is used in your country?

c) A protection strategy will generally include the implementation of different protective actions in time. In order to understand how your protection strategy is optimised, do you optimise protective actions within your strategy separately or in combination?

d) Do you optimise urgent protective actions (for example sheltering, evacuation, administration of iodine thyroid blocking)? If yes, how do you optimise these urgent protective actions?

e) What process do you plan to use for optimisation?

f) For whom and by whom will the plans be "optimised"?

g) Do you have any specific triggers for optimisation and their use?

COUNTRY	CZECH REPUBLIC
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	The optimisation strategy is based on the previous ICRP recommendations (60, 63, etc.). The ICRP 103 recommendations are intended to be implemented into an amendment of the Atomic law and related decrees. Any recommendation on detailed application of the process for optimisation of the protection strategy for emergency exposure situations could be very helpful. The Atomic Act (No.18/1997 Coll., as amended) states in the paragraph 4 of the section 4: *(4) Whoever utilises nuclear energy or performs radiation activities, prepares or performs interventions to reduce emergency, lasting or natural exposure must maintain a level of nuclear safety, radiation protection, physical protection and emergency preparedness such that the risk to human life health and to the environment shall be kept as low as reasonably achievable, economic and social factors being taken into account. Implementing regulation shall establish the technical and organizational requirements and guidance levels of exposure, which are considered to be sufficient to demonstrate a reasonably achievable level or an alternative procedure to demonstrate this level.* Hereafter, the Atomic Act states in the paragraph 5 of the section 4: *(5) Intervention aimed at averting or reducing an exposure shall always be performed if the exposure:* *a) approaches or without the intervention could approach levels at which acute damage to health is caused, or* *b) exceeds or without the intervention could exceed guidance levels set out in the implementing legal regulation and if expected reduction in health detriment due to intervention is sufficient to justify harm and costs related to the intervention. Implementing legal regulation shall establish guidance levels and details on rules for preparation and undertaking of intervention.* An implementing legal regulation – the Decree No 307/2002 Coll. on radiation protection, as amended, sets details in its Chapter III Intervention in Radiological Emergencies (sections 98 – 100). The general principles are defined in the Section 98 Countermeasures: *(1) The reduction of both personal and environmental exposures during a radiological emergency shall be applied by the following protective measures:* *a) early countermeasures involving sheltering, stable iodine administration, and evacuation; and* *b) long-term countermeasures involving relocation, control of radionuclide contaminated foodstuffs and water and control of radionuclide contaminated fodder.* *(2) The countermeasures in radiological emergencies shall always be implemented if these are justified by a greater benefit compared to the costs and damage caused by emergencies, and they shall be optimised in their form, scope and duration to bring the most reasonably achievable benefit as possible.* *(3) As a basic guidance for making decision on implementing the countermeasures, the guidance levels shall be applied which reflect a current status of knowledge and international experience about the facts that a given countermeasure brings a greater benefit than damage. For particular radiation activities and ionising radiation sources to which a risk of radiological emergency is related, the intervention levels specific for a given radiation activity or a ionising radiation source shall be set out in emergency plans based on the optimisation of radiation protection and the data specific for each particular event.* *(4) The data specific for determining the intervention levels in accordance with paragraph 3 shall involve the data on settlement and infrastructure in the vicinity of the ionising radiation source that affect the expected collective doses and the feasibility of countermeasures, namely: (a) presence of specific groups of the population, namely in hospitals, old people's homes, community care homes, and prisons;(b) traffic situations; c) high density of population; and d) presence of a large city.* *(5) During making decision on the acceptance of countermeasures in a radiological emergency, it shall be necessary to take into account the fact that a current situation shall not remarkably differ from the conditions when the intervention levels were laid down. For a simultaneous occurrence of a radiological emergency and a radiological emergency after different accident, for example, an accident with leakage of chemical harmful substance, or after a natural disaster, it shall be necessary to consider whether the introduction of countermeasure increases or not the damage arising from the other accidents or disasters in a scope greater than the benefit from exposure reduction.* In the following sections 99 and 100, the early and the long-term countermeasures are described in more details referring to intervention levels in the Annex 8.

How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	It depends on an event. Generally, several protective actions could be used in the same time.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	There are intervention levels for urgent protective actions. See below.
What process do you plan to use for optimisation?	There is no process for optimisation of protective action at this moment.
For whom and by whom will the plans be "optimised"?	-
Do you have any specific triggers for optimisation and their use?	-

COUNTRY	FINLAND
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	Overall protection strategy is described in the guides concerning protective measures during early and intermediate phases of a nuclear or radiological emergency. The guides are written by Radiation and Nuclear Safety Authority (STUK) but put into force by the Ministry of the Interior. In preparing the guides feedback was requested from a large group of stakeholders (e.g., governmental, regional and local authorities, licensees and private sector). The content of guides have been tested in various large-scale exercises with different scenarios (e.g., severe NPP accident, INEX 4), and utilized during Fukushima accident. The guides emphasize optimisation process in recommending and deciding upon protective measures, and comparing residual dose to chosen reference level. However, it is recognized in the guides that during an emergency there are many factors (e.g., prevailing circumstances, timing, resources, capabilities, social and ethical factors, financial consequences) affecting decision making and radiation exposure is only one of them. The higher doses the more dominant factor exposure is and vice versa.
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	Both. • Each protective measure has its own criteria above which action is needed, but this does not mean that below the specific criteria of an action, protective measure will not be initiated. Protective measures may be carried out even on low level of exposure (below 1 mSv) especially when they are easy and sensible. • During response phase protective measures will be carried out in combination e.g. in early phase sheltering indoors + iodine prophylaxis + access control + measures concerning agriculture and production. During intermediate phase combination of protective measures may be e.g. short term evacuation + decontamination + access control and restrictions of use of natural environment + measures concerning agriculture and production.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	During sudden event, urgent protective measures will be initiated based on pre-defined protection strategy and respective triggers for various types of emergencies (such as NPP accident, malicious act). In defining the strategy and triggers (e.g. OILs), optimisation has been taken into account.
What process do you plan to use for optimisation?	Radiation and Nuclear Safety Authority (STUK) as a competent authority makes safety assessments of development of situation with respect to safety of population, environment and society. Based on its safety assessment STUK during nuclear or radiological emergencies issues recommendations and advice on what protective measures should be considered to carry out. Recommendations and advice are always supplemented by reasoning (including magnitude of exposure and effectiveness of protective measures) for decision making process. STUK only use optimisation with respect to exposure, but in decision making process other factors are included in optimisation.
For whom and by whom will the plans be "optimised"?	STUK is the key advisory body in recommending protective measures to all organizations having responsibility to take care of the situation. The number of decision making organizations is numerous. STUK in its recommendations takes into account optimisation. However in decision making other factors play a role in optimisation process.
Do you have any specific triggers for optimisation and their use?	The guides concerning protective measures, there are operational intervention criteria of all protective measures as well triggers such as plant conditions, duration of sheltering etc. The triggers have been developed taking into account different kind of nuclear or radiological emergencies and the chosen reference level.

COUNTRY	**FRANCE**
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	For emergency exposure situations, present French legislation and regulations require optimisation of the protection of both intervention personnel and population. Intervention levels, expressed in terms of projected effective dose or projected equivalent dose to thyroid, are fixed by the regulations and implemented during the emergency phase. The numerical values fixed by the regulations take into account the optimisation of the protection of the population. For existing exposure situations, present French legislation and regulations require optimisation of the protection of both intervention personnel and population. The regulations specify that a ministerial order can fix levels, expressed in doses, above which actions are implemented. In the management of contaminated areas, the ASN policy is to optimise the protection of the population, in a case by case approach. The objective is to clean completely the contaminated areas, and as low as reasonably achievable if total cleaning is difficult to be reached.
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	-
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	The protective actions of the population (sheltering, evacuation, administration of iodine thyroid blocking), required by the regulations and implemented during the emergency phase, are optimised: they may be combined and take into account the nature of the concerned installation, the type of the accident and the prevailing circumstances of the situation.
What process do you plan to use for optimisation?	-
For whom and by whom will the plans be “optimised”?	For emergency exposure situations: During the emergency phase, within the advice of ASN, the “prefet” (local administration) decides the implementation of all or part of the protective actions of the population, including its information, with the participation of the responsible of the concerned installation. For existing exposure situations, present French legislation and regulations require optimisation of the protection of both intervention personnel and population.
Do you have any specific triggers for optimisation and their use?	There are no specific triggers for optimisation.

COUNTRY	GERMANY
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Emergency exposure situations: Decisions about protective actions in the pre-release phase are based upon projected doses, which are compared against intervention levels. Such intervention levels exist e.g. for the dose from external exposure over 7 days and the dose commitment from inhalation of radionuclides. This approach already considers those pathways which dominate the total dose in most accident scenarios. During the release phase early measurements of the gamma dose rate – obtained from automatic monitoring networks and deployable monitoring stations – are used to optimise the protection strategy by e.g. enlarging or adapting areas with protective actions. After the passage of the radioactive plume mobile monitoring teams and airborne monitoring units are used to characterize the affected area and to improve the assessment of doses. At that time the current protection strategy is checked against this information and possibly revised again. For existing exposure situations, resulting from an emergency no process for optimisation is established. For existing exposure situations, resulting from an emergency it is assumed that sufficient time will be available during the transition from an emergency to an existing exposure situation, in which the process of optimisation can be established.
How do you define optimisation strategy as it is used in your country?	Optimisation in emergency exposure situations is understood as a permanent revision of the current protection strategy in the light of new information becoming available (especially monitoring data).
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	In principle protective actions are optimised separately – as separate intervention levels exist for several protective actions -, but the impact of actions on other protective actions is being considered.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	The description as given before is mainly valid for urgent protective actions.
What process do you plan to use for optimisation?	The process includes regular briefings and discussion about the current radiological situation, in which revision of the protective strategy can be proposed.
For whom and by whom will the plans be "optimised"?	The plans will be optimised by the crisis organization in charge; the plans serve the protection of the public.
Do you have any specific triggers for optimisation and their use?	No

COUNTRY	IRELAND
	General comment: While optimisation has been used in preparedness activities, it has not been used for response as the only response required in recent years has been the response to Fukushima where the doses in Ireland were extremely low. Thinking on this topic has also been heavily influenced by the fact that the closest nuclear facility to Ireland is 110 km away.
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	No formal process has been established but the concept of optimisation is ingrained in the approaches used to develop advice and guidance in this area.
How do you define optimisation strategy as it is used in your country?	-
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	In combination. For example, for a nuclear accident, protective actions such as sheltering and agricultural countermeasures need to be considered in tandem. Due to Ireland's distance from any nuclear facilities, sheltering would provide a small dose saving, as compared to implementing agricultural countermeasures such as removing dairy cows from pasture – which would require farmers to not shelter (or delay sheltering) but could significantly reduce ingestion dose. [Liquid milk is one of the few food products that it is anticipated that replacements might not be easy to find 'uncontaminated' replacements for if the agricultural countermeasure is not taken early on]. Similarly, for a near-shore nuclear-powered vessel accident that might warrant iodine prophylaxis, sheltering/temporary evacuation would be considered in conjunction with this protective action – time allowing.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	It would depend on lead-in time to the release. Time allowing, it is anticipated that the immediate (reflex) advice for a scenario which might warrant any urgent protective actions would be shelter ('go in, stay in, tune in') and after that the radiological advice would be considered in terms of the dose saving from one or a combination of protective actions, together with social/economic factors such as size of population to be sheltered/prevailing weather/vulnerable populations potentially affected.
What process do you plan to use for optimisation?	The approach that has been used for preparedness is to consider total dose from all the main exposure pathways; identify the main potential pathways where doses can be reduced and use this to prioritise preparedness activities (e.g., for nuclear facility accidents the distance of Ireland from such facilities, means that approx 90% of the dose would likely come from food consumption – assuming no protective actions – thus, protective actions for food/agriculture has been the focus of preparedness for this scenario). For response it is anticipated that the projected doses would be modelled based on available information, together with the dose saving (and hence projected residual dose) following protective actions singly and in combination. This information would inform the radiological protection advice – which would then be considered by an inter-governmental advisory/decision making committee which will also consider the social/economic factors.
For whom and by whom will the plans be "optimised"?	See above.
Do you have any specific triggers for optimisation and their use?	None formally established but can consider that it would be triggered any scenario where there is a potential for doses that cannot be considered trivial (mSv range) and where there is time to perform optimisation.

COUNTRY	JAPAN
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	The optimisation strategy in Japan will be defined based on the concept of the ICRP protective actions for the emergency exposure situation and the existing exposure situation of in consideration of the modification of the international radiation standards.
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	The optimisation of the protective strategy is planned by using the reference level. At the planning phase, the reference levels are used to judge the suitability of the protective actions and at the response phase the effectiveness of the protective actions are examined.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	The procedure development is planned to make an urgent decision based on the framework of the above-mentioned international standards. The decision rule is implemented by the concept of the emergency class (EC) identified by the emergency action level (EAL) and operational intervention level (OIL) based on the general criteria.
What process do you plan to use for optimisation?	In the previous guideline that Nuclear Safety Commission of Japan settled on, regarding the emergency preparedness and response, the concept of the optimisation of the protective action has not been defined clearly. The concept of optimisation to take into account the experience of the Fukushima accident based on the international framework will be clearly implemented in the concept of new guideline.
For whom and by whom will the plans be "optimised"?	It is one of responsibility of the Regulation Agency and the Nuclear Safety Commission of Japan to take care of optimising the protective action plan for the resident.
Do you have any specific triggers for optimisation and their use?	Japan has specific triggers of experience of the protective action execution after the Fukushima accident.

COUNTRY	**ROMANIA**
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	We have defined in the Romanian legislation not values but intervals of values as generic intervention levels for implementing protective actions to population. Below the lower limit of the interval there is no need for implementing the respective protective action. Nevertheless, even in such cases, some actions might be needed and have to be considered in order reducing as low as possible the radiation doses to the affected population. In between the lower and the upper limit of the interval, the experts have to consider the combination of different protective actions to reduce the radiation doses to population. Above the upper limit, the respective protective action shall be implemented in any case. This is the mechanism for optimising the response strategy in different emergency situations.
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	In combination.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	Yes. The optimisation can be performed when taking into consideration one or more factors: the moment of implementation, duration of implementation, combination of different protective actions. For example, in case of a radioactive emission in the atmosphere, restrictions on food and water consumption will be imposed immediately, together with sheltering or evacuation, in the very early hours, even before measuring the radioactive content of food and water. With such action, the ingestion of radioactivity is avoided from the beginning of the accident. Other combinations might be envisaged, taking into account the situation occurred.
What process do you plan to use for optimisation?	As mentioned above.
For whom and by whom will the plans be "optimised"?	Optimising the plans is a distinct process and has no direct connection with the optimisation of a protection strategy. Plans are usually optimised after exercises or events which demonstrate that some aspects have to be revised, updated or improved. The response strategy is part of the response itself.
Do you have any specific triggers for optimisation and their use?	Yes. The generic intervention levels for urgent protective actions implementation, defined as intervals and not single values are used as triggers.

COUNTRY	**UNITED STATES OF AMERICA**
Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?	Yes
How do you define optimisation strategy as it is used in your country?	Protective Action Guidance provides risk-based action levels as dose to be avoided by specific protective actions over Emergency and Intermediate phases of an emergency.
How is your protection strategy optimised, do you optimise protective actions within your strategy separately or in combination?	Incident-specific decisions must be made, weighing safety and other factors when ordering shelter-in-place, evacuation, or a combination of both over time. As more information becomes available, refinements of the affected area recommendations can be made.
Do you optimise urgent protective actions? If yes, how do you optimise these urgent protective actions?	Some U.S. states have opted to pre-deploy KI for members of the public near nuclear power plants. Others rely on evacuation. KI is part of the Strategic National Stockpile for wide-area disaster response. All communities near nuclear power plants have prescriptive emergency actions based on plant conditions which are practiced regularly.
What process do you plan to use for optimisation?	The process is described in the Protective Action Guides (PAGs) Manual (pub. 1992).
For whom and by whom will the plans be “optimised”?	Members of the public are protected from radiation emergency exposure by their state and municipal emergency management organizations, often based on PAGs.
Do you have any specific triggers for optimisation and their use?	The trigger would be a projected dose approaching a PAG level. In this sense, reference levels are given in terms of dose to avert.

COUNTRY	Have you established a process for optimisation of the protection strategy for emergency exposure situations and existing exposure situations resulting from an emergency?
THE NETHERLANDS	No. Still working on a strategy for optimisation.
SWITZERLAND	Not Yet. Recently, the national response system for nuclear and radiological emergencies was transformed into a new organization covering all emergency and crisis situations in the field of NR, B and C and natural disasters with national impact. The new ordinance was approved by the Federal Council in October of last year and took effect on 1 January of this year. This multi-threat approach had no major changes on the previous organization for NR emergencies as it was based on this model. The legal basis for decisions on protective actions was laid down in an appendix as integral part of the ordinance. The intention was to amend this appendix according to the new international recommendations. The timeframe for the revision of the ordinance did not allow to perform the necessary analysis and to work out the proposals how to implement the new recommendations. It was decided that these amendments will be part of the next revision of the relevant ordinances which are planned to take place next year. This will, in addition, allow taking into account the experience gained during the accident of Fukushima. Some preliminary work has already started but is still in a very preliminary stage.
SPAIN	No. Still working on a strategy for optimisation. An update of national emergency rule will be published next year.

PART 2 "Reference Levels"

"Reference levels" in ICRP Publication 103 and IAEA BSS - selected Quotations

ICRP Publication 103 states that "… Reference level, in emergency or existing controllable exposure situations, this represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration.''

IAEA BSSs state that "…Reference levels are used for optimisation in emergency exposure situations and existing exposure situations. These are established or approved by the government, regulatory body or other relevant authority. For occupational and public exposure in emergency exposure situations and existing exposure situations, a reference level serves as the boundary in defining the range of options in optimisation for implementing protection actions. The reference level represents the level of dose or risk above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection is implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration. The optimised protection strategies should keep exposure levels below the reference level. Once an emergency exposure situation has occurred or an existing exposure situation has been identified, actual exposures may be above or below the reference level, which would then be used as a benchmark to judge whether further protective measures are necessary and to assist in prioritising their application. Optimisation is to be applied in emergency and existing exposure situations, even if the initial doses are below the defined reference levels…"

Do you use reference levels?

If No:

a) Why not?

If Yes:

b) What are your national criteria in setting reference levels?
c) How are they used (in planning, in response phase, etc.)?
d) What process/authority establishes the reference levels?
e) Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?
f) Do you have any specific triggers for specific reference levels?
g) Are reference levels "event specific"?
h) What dose quantities are used (projected residual, averted, and received)?
i) Do you have any process to adjust the reference level in transition from early to intermediate and to long term phase?

If yes, please briefly describe the process and indicate the roles of the participating entities.

If not yet, do you intend to in the future?

COUNTRY	**CZECH REPUBLIC**
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	Intervention levels are established on the base of the ICRP 60 and 63 recommendations. Upper bounds of the intervention levels can be considered to be reference levels. The intervention levels were established by the State Office for Nuclear Safety (a regulatory authority) in the Decree No. 307/2002 Coll., as amended in 2005, in the sections 99 and 100: Section 99 Early countermeasures *(1) An early countermeasure shall always be considered reasonable if the expected exposure of an individual might directly lead to his and her health damage, and hence the countermeasures will always be introduced if it is expected that absorbed doses might exceed the levels given in Table 1 of Annex 8 during less than 2 days for any person.* *(2) If a countermeasure might avert or reduce in the critical group of the population for the time not longer than 7 days the exposure exceeding the lower maximum permitted level of the span of guidance levels of intervention levels as laid down in Table 2 of Annex 8, the implementation of countermeasures shall be considered with respect to its scope, feasibility, and expensiveness of countermeasures and its possible consequences; if the upper maximum permitted level is exceeded, the countermeasures shall usually be implemented.* *(3) To implement and evaluate the scope of early countermeasures, the following guidance levels shall be followed as a specifying guidance:* *a) for sheltering, an averted effective dose of 10 mSv for a period of sheltering equal or shorter than 2 days;* *b) for stable iodine administration, an averted committed equivalent dose of 100 mSv in thyroid gland induced by iodine radioisotopes; and* *c) for evacuation, an averted committed effective dose of 100 mSv over a period of evacuation not longer than 1 week.* Section 100 Long-term countermeasures *(1) For recovery countermeasures, the guidance levels of intervention levels shall be laid down in Table 3 of Annex 8. Projected effective or equivalent doses which, if the corresponding remedial measures are not implemented, would be received from all pathways of external exposure and radionuclide intake by inhalation and ingestion over the first year after the radiation accident, and for the control of contaminated foodstuffs and water only due to radionuclide intake by ingestion over the first year after the radiation accident shall be compared to these guidance levels.* *(2) For the control of foodstuffs production and import, and the introduction of foodstuffs into the market according to the special act28), the maximum permitted limits of radioactive contamination of foodstuffs given in Table 4 of Annex 8 shall be effective for radioactive foodstuffs contamination during a radiation accident or a radiological emergency until the admission date of the Czech Republic to the European Union.* *(3) To make a decision on relocation, the following guidance levels of intervention levels shall be accepted as a specifying guidance: (a) for commencement of a temporary relocation, an averted effective dose shall be 30 mSv for a period of 1 month; (b) for termination of the temporary relocation, a projected effective dose shall be 10 mSv for a period of 1 month. If it is proved within 1 up to 2 years that the total effective dose within 1 month shall not drop below the intervention level for the termination of temporary relocation, permanent relocation shall be considered; and (c) for permanent relocation the projected lifetime effective dose shall be 1 Sv.* The ICRP 103 recommendations are intended to be implemented into an amendment of the Atomic law and related decrees.
How are they used? (in planning, in response phase, etc.)?	The intervention levels are used both in planning and response phase.
What process/authority establishes the reference levels?	The intervention levels were established by the State Office for Nuclear Safety on the base of the ICRP 60 and 63 recommendations.
Who uses reference levels and to what extent? (regulators, operators, response planners and decision makers, etc.)	Regulator uses the intervention levels in response planning and in the case of emergency for an advice to decision maker.
Do you have any specific triggers for specific reference levels?	See above.

Are reference levels “event specific”?	No, the intervention levels are general.
What does quantities is used (projected residual, averted, received)?	Depending on the specific protective measures, the intervention levels use the quantity of the projected or residual dose.
Do you have any process to adjust the reference level in transition from early to intermediate and to long term phase? Please briefly describe the process and indicate the roles of the participating entities.	Not yet.

COUNTRY	THE NETHERLANDS
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	-
How are they used (in planning, in response phase, etc.)?	In the planning phase to determine "planning zones" in which countermeasures should be prepared. In the response phase to determine if countermeasures should be taken.
What process/authority establishes the reference levels?	Reference levels are established by the ministry of Economic Affairs, Agriculture and Innovation.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	They are used by operators and response planners to prepare for an accident and to determine planning zones. Decision makers use reference levels during an emergency to decide whether countermeasures should be taken.
Do you have any specific triggers for specific reference levels?	No
Are reference levels "event specific"?	No
What dose quantities are used (projected residual, averted, received)?	Projected dose
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	No

COUNTRY	FINLAND
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	The reference level is described in the guides concerning protective measures during early and intermediate phases of a nuclear or radiological emergency. The guides are written by Radiation and Nuclear Safety Authority (STUK) but put into force by the Ministry of the Interior. In preparing the guides feedback was requested from large group of stakeholders (e.g. governmental, regional and local authorities, licensees and private sector). The reference level of 20 mSv was chosen also to reflect dose limit for emergency workers. The reference level is a goal, not a strict dose limit.
How are they used (in planning, in response phase, etc.)?	Reference level is used in planning an optimized intervention strategy taking into account e.g. possibilities and resources carry out protective measures in our society. Reference level is used during response phase, too, when actual measures need to be launched. However, it is recognized that during an emergency there are many factors effecting decision making, and radiation exposure is only one of them. The higher doses the more dominant exposure factor is and vice versa. Being close or above of chosen reference level, exposure becomes the dominant factor.
What process/authority establishes the reference levels?	Radiation and Nuclear Safety Authority (STUK), as a competent authority and the key expert body giving during nuclear or radiological emergencies recommendations and advice for protective measures.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	Mainly STUK in estimating exposure of population and providing recommendations for protective measures. However, the Ministry of the Interior in putting guides into force supports use of chosen reference level among stakeholders.
Do you have any specific triggers for specific reference levels?	The guides concerning protective measures, there are operational intervention criteria of all protective measures as well triggers such as plant conditions, duration of sheltering etc. The triggers have been developed taking into account different kind of nuclear or radiological emergencies and the chosen reference level.
Are reference levels “event specific”?	No. The reference level defined in the guides for protective measures is general and applied to all kind of situations.
What dose quantities are used (projected residual, averted, received)?	Reference level is described as residual dose during first year after the event. In estimating residual dose during an emergency all exposure pathways and effectiveness of actual protective measures are taken into account.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	Yes. Management of the radiation situation may take years altogether. Throughout this period the primary goal is to reduce the annual exposure to the population to a level that is seen as permanently acceptable. Lowering reference level will most probably be responsibility of decision making bodies based on STUK’s proposal and with support of political level.

COUNTRY	**GERMANY**
Do you use reference levels?	Yes. The intervention levels in place in Germany can be considered as reference level, since these represent dose levels, above which it is judged to be inappropriate to plan to allow for exposures to occur.
What are your national criteria in setting reference levels?	Reference levels were set based on the typical levels of yearly and lifetime exposure due to natural radiation in Germany, the severity of the disruption of the daily life of population affected by protective actions, and generic emergency scenarios.
How are they used (in planning, in response phase, etc.)?	Mainly in the response phase, partially also in planning.
What process/authority establishes the reference levels?	The "Strahlenschutzkommission (SSK)", which is the highest committee providing advice in radiation protection to the federal government, recommends the reference levels and the federal government puts them in force.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	All organizations involved in emergency preparedness and management use these reference levels as basis of their work.
Do you have any specific triggers for specific reference levels?	No official operational intervention levels derived from the reference levels itself are in use at the moment.
Are reference levels "event specific"?	No, generic.
What dose quantities are used (projected residual, averted, received)?	Only projected doses.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	No.

COUNTRY	IRELAND
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	Heavily influenced by EU directives and recommendations. Also consider practicality of implementation, international guidance, projected doses from scenarios considered in planning and reference levels adopted by neighboring countries.
How are they used (in planning, in response phase, etc.)?	To date, in planning only – but would be used in early phase of response as a metric for determining if enough is being done/proposed to protect the population.
What process/authority establishes the reference levels?	Recommended by Radiological Protection Institute of Ireland to lead government department (LGD) responsible for nuclear/radiation emergency plans – adopted by LGD.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	Used mostly by response planner/advisors in radiation protection organization, this is also the national regulatory organization. Also considered by other Government Departments (including response planners and potential decision makers) but guided strongly by advice given by radiation protection organization advisors.
Do you have any specific triggers for specific reference levels?	Any scenario that could give rise to non-trivial doses.
Are reference levels "event specific"?	Not specifically, but there are different operational interventional limits based on different event categories.
What dose quantities are used (projected residual, averted, received)?	Current adopted levels were based on averted dose but we are moving to using projected residual in our preparedness/response activities.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	No plans to formalize this. We can envisage that it will be very event specific and as the number of entities in Ireland is small, roles are well defined with little overlap and the advisors/decision makers are nearly all well known to each other (hence building trust in advice given), no significant problems are predicted for adjusting the reference levels as the event progresses (based on expert radiation protection advice coupled with social/economic factors).

COUNTRY	**JAPAN**
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	The following are the national criteria for integrated dose at the time of the accident; (a) Criteria in the emergency situation are 20-100 mSv in the case of accident continuation. (b) Radiation protection criteria in the situation where contamination from past accidents should be taken into the consideration are 1-20 mSv/year.
How are they used (in planning, in response phase, etc.)?	They will be used in the all phases of planning, response and recovery.
What process/authority establishes the reference levels?	The Regulation Agency and Nuclear Safety Commission of Japan will be responsible to establish the reference levels by several processes such as discussion between specialists.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	All stake-holders such as regulators, operators, response planners and decision makers, etc. use reference levels according to the content of their activities.
Do you have any specific triggers for specific reference levels?	Yes, Japan has specific triggers of experience of the protective action execution after the Fukushima accident for specific reference levels.
Are reference levels "event specific"?	No. The event specific reference level would not be considered.
What dose quantities are used (projected residual, averted, received)?	Japan prefers to the level of the residual dose after the protective action execution.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	Yes. The radiation protection criteria for public in accident were as follows ; (a) Criteria in the emergency situation (accident continuation) The criteria in the emergency situation was set by reference to the recommendation 2007 of ICRP in which 20-100 mSv is suggested as a reference level to protect public in the emergency exposure situation and IAEA safety guidance GSG2 "Preparedness and Response for a Nuclear or Radiological Emergency" (2011) in which the countermeasures for protection in the emergency situation describes to be in consideration of basic principle "Radiation exposure should be kept as low as reasonably achievable". Predicted integrated dose of 20 mSv per year from the accident onset is adopted as the criteria for the scheduled controlled evacuation area. (b) Radiation protection criteria in the situation where contamination from past accidents should be taken into the consideration In the 2007 recommendation of ICRP, a standard of "1-20 mSv per year" is provided as a reference level for protecting the public from contamination after accidents in existing exposure situation. And also, the principle of optimisation of protection, "ALARA (As Low As Reasonably Achievable)" is to be applicable to the existing exposure situation. They will be reflected for the radiological emergency plan development in the country, the licensee, and the local government through enhancement of the guidelines and regulations. We hope that the reference levels should be verified and protective actions should be enhanced as much as possible through the practice and lessons learned from the Fukushima accident.

COUNTRY	**SPAIN**
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	Following ICRP and IAEA recommendation reference levels are established to protect both public and emergency workers.
How are they used (in planning, in response phase, etc.)?	Spanish nuclear and radiological emergency rules are written thinking at planning and reflex phase more than intermediate or long term phase.
What process/authority establishes the reference levels?	The reference levels are established by CSN and issued in the basic emergency plan for emergencies at NPP and in the Civil Protection Law for emergencies in other kind of installation.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	Mainly used by Regulatory Authority to public and emergency workers at the decision maker process; operators also consider these reference levels to emergency response personnel.
Do you have any specific triggers for specific reference levels?	The reference levels are a triggers value themselves although sometimes at drills and exercises countermeasure recommendations are considered earlier.
Are reference levels "event specific"?	No
What dose quantities are used (projected residual, averted, received)?	Averted dose it is used for emergency response.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	It is not planned currently but it is a challenge to implement our legislation to intermediate and long term phases.

COUNTRY	**UNITED STATES OF AMERICA**
Do you use reference levels?	Yes
What are your national criteria in setting reference levels?	During normal conditions, Federal Guidance for the Public guides the limitation of exposure from all manmade and technologically enhanced sources (except radon). In an emergency, Protective Action Guidance is implemented to keep public exposures low.
How are they used (in planning, in response phase, etc.)?	The above criteria are used for facility regulation and then for emergency response preparedness exercises and drills.
What process/authority establishes the reference levels?	Laws establishing the Environmental Protection Agency gave this responsibility to our Agency.
Who uses reference levels and to what extent (regulators, operators, response planners and decision makers, etc.)?	PAGs are widely used in the U.S. nuclear power industry for offsite emergency preparedness activities and plans, per emergency response regulations overseen by Nuclear Regulatory Commission and the Federal Emergency Management Agency.
Do you have any specific triggers for specific reference levels?	The reference levels themselves serve as triggers, if dose projections approach PAGs.
Are reference levels "event specific"?	No
What dose quantities are used (projected residual, averted, received)?	Averted dose is used for emergency response, and projected residual dose is used for final cleanup decisions.
Do you have any process to adjust the reference level in transition from early to intermediate and to long-term phase? Please briefly describe the process and indicate the roles of the participating entities.	Yes. Early and Intermediate levels are recommended in the PAGs Manual, while long-term cleanup levels must be incident-specific.

Do you use reference levels?	**FRANCE**
	No. At the present time, the term of reference level is used in the French regulations for emergency exposure situations or existing exposure situations, in its common sense, not really as defined by ICRP. They will be used when implementing the draft EURATOM BSS in the national regulations. All the discussion within the French program CODIRPA on the management of post-accidental situations, including transition from early to intermediate and to long term phase, has taken into account optimisation of the protection of the population. The implementation of reference levels, in the sense of ICRP, are included in the conclusions and will be implemented in the national post-accident policy to be published mid-2012, in terms of effective doses, specially to set up areas for protecting the population and controlling foods and feed as well. However, to avoid misunderstanding by the stakeholders, the wording “guidance level” is preferred to “reference level”.
	ROMANIA
	No. The reference level is a rather new concept used by ICRP. It will be adopted in the Romanian revised specific legislation on EPR. Romania will adopt in the future in the Romanian legislation the concept of reference level. The proposal will be in the beginning to have one single reference level for any type of event, expressed as projected dose in the early phase and as residual dose for long term exposures. The proposal will be discussed with our counterparts and a decision will be taken by the group of experts representing the organizations composing the national system for the management of emergencies.

GENERAL RESPONSES TO THE SURVEY	
COUNTRY	**RESPONSE**
AUSTRIA	Currently the Austrian legislation regulating emergency and existing exposure situations (Radiation Protection Act and Ordinance on Interventions in Case of Radiological Emergencies and Lasting Exposure) is and has to be based on the EC Basic Safety Standards (Council Directive 96/29/EURATOM) and on different directly applicable Council Regulations (e.g. 87/3954/EURATOM and similar for laying down maximum permitted levels of radioactive contamination of foodstuff and feedstuff following a nuclear accident or a radiological emergency) . The new BSS on EC level which will implement the ICRP recommendation 103 are still under elaboration and discussion and therefore legally not effective. The responsible authorities in Austria have to wait for the new BSS before adapting the Austrian legislation. Therefore the current concept of emergency management in Austria is still based on the Council Directive 96/29/EURATOM and on the ICRP 60 (interventions, intervention levels for specific counter measures, etc.). Nevertheless in the Ordinance on Interventions in Case of Radiological Emergencies and Lasting Exposure specific procedures for optimisation counter measures in different phases of a radiological emergency exits: Evaluation and adjustment of intervention measures • The effectiveness of intervention measures under implementation has to be evaluated and if necessary intervention measures have to be adjusted or terminated by the competent authority. • Therefore regional authorities have to inform the competent authority (for making decisions on the intervention measures) on the status and the effectiveness of interventions measures under implementation.
RUSSIAN FEDERATION	The mentioned Conception with the associated questions is likely to be applicable for the majority of types and extents of radiological accidents. However, exclusive cases, such as the extremely high level of the radiological accident (7th level according to the international scale INES), and trivial incidents, may require different intervention criteria. The optimisation procedure and effectiveness of its implementation depend very much on the assessment of the significance of different pathways and factors of radiation exposure, and on organizational, technical, infrastructural and other features. Nevertheless, the decision of these problems should be in the understanding and competencies of national regulators, operator and all members of emergency response. The experience confirms that because of the lack of a coherent system of derived criteria and unified procedure of their application, the use of the ICRP Publication 103 can be justified only in general sense of the emergency planning ideology. Having in mind the brevity of the radiological accident development at the early stages and the need to make important decisions on the public protection during the first hours, you can use just simplified methods for the radiation survey. At that, 'strong-willed', administrative decisions (preventive response) should be taken into account. Therefore, in such case, application of one-level system of criteria is reasonable. Even application of the current Russian two-level system, according to NRB-99/2009 is not always justified. Moreover, in this context of the reference level, the effective dose usage is not quite clear for the purpose to evaluate the radiation exposure to the thyroid, and for example, in case of radiological accidents in the radioactive waste storage facilities – to the skin, and in case of dispersion of Tran uranium nuclides – to lung etc. Thus, implementation of the provisions of the ICRP Publication 103 in practice of emergency response, in its broadest sense, has a positive meaning, but needs elaboration and further development of optimisation procedures and methods based on the type and scale of the radiological accident and local circumstances.
THE UK	The Health Protection Agency is currently carrying a two year programme of work to update our emergency and recovery advice for radiation incidents and in doing so will be considering the recommendations of ICRP and the BSS (EC and IAEA). It is likely that HPA will be changing the current advice to some extent to adopt some of the new ICRP recommendations but at present it is not clear exactly how much this will be the case. Any changes to UK legislation and regulations will only follow the adoption of the new European BSS, which will have to be incorporated into UK legislation but where appropriate account will also be taken of the HPA advice.

ANNEX-2

Practical experience of Japan in decision making for protective actions during the Fukushima accident

Introduction

The nuclear emergency management system in Japan has been developed step by step since the accident at the Three Mile Island (TMI) nuclear power plant in the United States of America occurred in 1979. The Emergency Preparedness Guide was issued in 1980 by Nuclear Safety Commission (NSC) as one of the measures to maintain preparedness for severe accidents such as the TMI accident. The impact of the Chernobyl accident in 1986 on the emergency management system was not so significant because the differences between reactor types were emphasised. Several weaknesses such as prompt initial actions, collaboration of national and local governments, strengthening of emergency response system and the clarification of licensee's responsibilities were disclosed concerning emergency management system by the Tokaimura criticality accident in 1999. After the criticality accident, the Act on Special Measures Concerning Nuclear Emergency Preparedness was enacted in December 1999 and enforced in June 2000. Although the arrangement of the emergency management system in Japan has been made by means of legislation and infrastructure, several weaknesses of the system were also found related to radiation protection. The decision making process for implementing protective actions relied heavily on the computer-based predictive models. The criteria for terminating urgent protective actions and also for long-term protection actions such as temporary relocation have not been prepared in the NSC emergency preparedness guide.

The NSC emergency preparedness guide was based on the recommendations in ICRP Publications 60 (1991) and 63 (1992). The International Basic Safety Standards (BSS) by the International Atomic Energy Agency (IAEA) took into account the recommendations issued by ICRP and provided guidelines for intervention levels for urgent protective actions and action levels for foodstuffs (IAEA, 1996). NSC has adopted these guidelines for intervention levels and action levels in the emergency preparedness guide. Recently ICRP issued the 2007 Recommendations described in ICRP Publication 103 (2007), which evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations. Applications of the Commission's Recommendations for both emergency and existing exposure situations have been issued as ICRP Publications 109 (2010) and 111 (2010), respectively. At the time of the Fukushima accident, the change in the ICRP approach has not yet being incorporated into international standards as well as national ones and could have been part of the problem.

This annex briefly describes the initial lessons learned from the Fukushima accident. In particular, it discusses some radiation protection issues on emergency preparedness and response at the early stage of such a large scale severe nuclear accident.

Radiological situation at an early stage of the accident

In the area of the Fukushima Daiichi nuclear power plant, the circulation of sea and land breezes is a predominant factor for dispersion of released radioactivity. At night, the wind blows toward the sea. In the early morning, it shifts to the south, and after that to the southwest and west. From afternoon to evening, it blows to the northwest and north. Figure 1 shows the off-site ambient dose rate measurements relatively far from the

Fukushima Daiichi site to describe the radiological situation at the early stage of the accident. The first peak of the airborne dose rate was observed at Minamisoma city, about 20 km north of the plant at about 20:00 on March 12. This might be a result of the radioactive plume transported by the strong southerly winds at the time of the venting of Unit 1 and the later hydrogen explosion in the reactor building. The main releases from Unit 3 on March 13 and 14 were almost transported toward the sea.

In the middle of the night on March 14, Unit 2 also went through a core melt and the onsite radiation levels began to rise. Further, at around 06:00 on March 15, there was a large impact noise and vibrations in the area of the suppression chamber of Unit 2. Outside the reactor site at 04:00, radiation levels as high as 24 µSv per hour were observed at Iwaki city about 50 km south of the plant. During this time the prevailing winds, which were from the north, carried the radioactive plume to Ibaraki prefecture, Southern Kanto area, and even as far as Shizuoka prefecture. After that, in the afternoon, the radioactive plume reached the cities of Shirakawa, Koriyama and Fukushima with moving clockwise, and the airborne radiation levels rose. In the evening of March 15, the entire prefecture of Fukushima experienced rain and snow, depositing the radioactivity on the ground during the plume passage. The areas to the northwest of the nuclear power plant were thus highly contaminated. The Ministry of Education, Culture, Sports, Science and Technology (MEXT), in cooperation with the US Department of Energy conducted airborne monitoring within the 100 km surrounding the power plant. According to the radiation map produced by this monitoring, the total depositions of caesium-134 and 137 on the ground were strongly affected by the precipitation that fell during the time the plume passed over and showed a non-uniform distribution as shown in Figure 2.

Figure 1. Ambient dose rates observed at seven cities around the Fukushima plant at the early stage of the accident

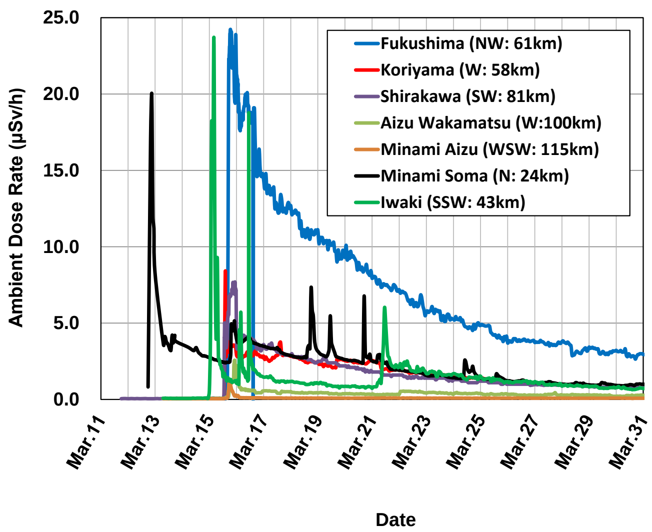
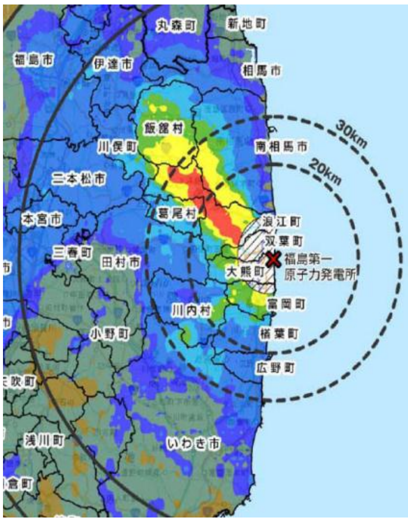


Figure 2. Surface deposition of Cs-137 resulted from airborne monitoring by MEXT and DOE



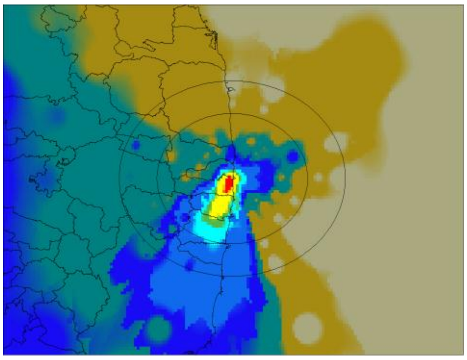
Urgent protective actions

In order to avert potential radiation exposure to the public, the Japanese Government implemented the precautionary urgent protective actions of advising those within initially a 3 km radius of the plant to evacuate and those within a 10 km radius to stay in house on March 11. This was determined on the basis of the plant situation that the reactor Unit 1 has not been cooled. The Government officially reported that the evacuation had been completed at the mid night on March 12. Then the implementation was quickly extended to a 10 km radius evacuation zone early on March 12, and then later to a 20 km radius evacuation zone after the hydrogen explosion of Unit 1. This was because the pressure in the primary containment vessel could possibly be increasing and also for preparing for any possible risks which would occur simultaneously at multiple reactors including the units other than Unit 1. Then, "in house" sheltering zone between 20 to 30 km radius from the site was set up on March 15. The Nuclear Industrial and Safety Agency (NISA) announced that the evacuation of 20 km zone had been completed at 19:00 on March 15. These precautionary urgent protective actions were taken on the basis of the plant risk.

In emergency exercise so far, recommendations of implementation of urgent protective actions have been made based on projected dose (in fact "predictions") with intervention levels. The NSC guide describes that the projected dose will be evaluated by the models which predict source terms for the accident to be considered and the does to the public by using the source terms. This procedure is adopted in the National Basic Response Plan with the computer prediction system to be assigned. The Emergency Response Support System (ERSS), which predicts the accident progression of the plant, could not be utilised in the Fukushima accident because necessary information from the plants could not be obtained. In addition, the System for Prediction of Environmental Emergency Dose Information (SPEEDI), which conducts a numerical forecast of variations of atmospheric conditions, air concentrations and depositions of released radioactivity and dose distributions, could not be utilised because source term information could not be obtained.

After the accident, the issue relating to disclosure of the results generated by SPEEDI to the public was raised by media and also discussed in the Diet. The criticism pointed out that if the information generated by SPEEDI were provided timely, it could have helped local governments and population to choose more appropriate route and direction of evacuation. However, neither quantitative nor even qualitative analyses have not been presented to support such discussions. Figure 3 shows the results of caesium-137 deposition patterns calculated by Level 3 PSA code, OSCAAR developed at Japan Atomic Energy Agency (Homma et al., 2005) using source terms presented in the Government report on the Fukushima accident to the IAEA submitted in June 2011. The source terms were calculated with a severe accident analysis computer code MELCOR by NISA. The differences between Figure 2 and Figure 3 are mainly due to the release timing of caesium-137 calculated by MELCOR and also contributed by uncertainty of the atmospheric dispersion model used. This highlights the difficulty of protective action recommendations based on computer-based dose predictions.

Figure 3. Surface deposition of Cs-137 calculated by OSCAAR using source terms provided by MERCOR



When implementing urgent protective actions, there is no time to undertake detailed exposure assessments in real time. There are also extremely large uncertainties associated with predictive models. It is therefore necessary to determine, in advance, a set of internally consistent criteria for taking such actions, and, based on these criteria, to derive appropriate "triggers" for initiating them in the event of an emergency as described in ICRP Publication 109 (2010). IAEA recommends that precautionary urgent protective actions should be taken before or shortly after a major release on the basis of plant conditions and should not await a release. A Safety Guide published in 2011 (IAEA, 2011) provides the basis for the emergency classification schemes and an example of emergency action levels that are criteria for classification.

Restrictions on food and water

After the high contamination on the ground of northwest area occurred on March 15, high levels of radioiodine and radiocaesium concentrations were detected in foodstuffs and water. Radioiodine in tap water was first detected on March 16 in Fukushima city. Following this, on March 20, water samples taken in Iitate village were found to have iodine-131 levels of 965 Bq/kg, exceeding the recommendations by NSC, which are set at 300 Bq/kg. For this reason, the Ministry of Health, Labour and Welfare (MHLW) restricted consumption of water from private water supply systems. Kinase et. al (2010) reported that the averted thyroid equivalent dose to infants in Iitate village was estimated at about 8 mSv, though the effective half-life of concentration of iodine 131 in tap water was observed as about 2.8 days. In addition, on March 21, MHLW announced that people should avoid using tap water for infants, for such things as making baby formula. This measure was enacted throughout March in several prefectures including Tokyo around the Fukushima plant.

In Kawamata village on March 16, raw milk was found to contain 1,190 Bq/kg of iodine-131 which exceeds the provisional regulatory value of 300 Bq/kg by MHLW. Further, on March 18, in Hitachi of Ibaraki prefecture, 54,100 Bq/kg of iodine-131 and 1,931 Bq/kg of caesium were detected in spinach. This also exceeded the recommended levels. Since

March 21, when Fukushima prefecture enacted restrictions on the distribution of raw milk, it has enacted similar distribution and consumption restrictions on vegetables. The restrictions of those foodstuffs began on March 21. At later stage of the accident, caesium was found in Shitake mushroom in April, in tea plants in May, moreover, in July, beef cattle that were found to have been fed with contaminated rice stalks was found to have unacceptably high levels of caesium-137 and distribution of beef was restricted for four prefectures.

Radioactivity in food and drinking water has caused significant public anxiety and also rumour effect. Conceptually protective actions on food consumption can be implemented for each different type of exposure situation because the transfer of radionuclides into food chain depends upon the time and characteristics of the contamination. At the early stage, quick response is needed to avert ingestion dose from elevated levels of radioactivity such as radioiodine directly deposited on agricultural products and drinking water. This can be taken for triggering restrictions by using an operational intervention level such as gamma dose rate from contaminated surface suggested by IAEA (2011). At the intermediate and longer term stage, criteria for foodstuff restrictions should be considered in the process of optimisation for the whole protection strategy, considering such factors as radiological and nutritional impact, reference level and contribution of ingestion dose, realistic estimates based on dietary habits and market dilution and harmonisation to internationally agreed standards.

Early protective actions

On March 17, a highest value of 170 μSv/h of ambient dose rate was observed at a point outside 30 km from the site. NSC collected monitoring data around those heavily contaminated areas and gave an advice to the Nuclear Emergency Response Headquarters to request residents to voluntarily evacuate from those areas where relatively high dose was expected. After reviewing the situation, NSC has been considering the modification of the urgent protective actions implemented and the process of implementing temporary relocation of residents in those areas. Meanwhile IAEA advised Japanese Government to carefully assess the situation on March 30 because one of the IAEA operational criteria for evacuation was exceeded in Iitate village. IAEA provided operational intervention levels for field survey measurements such as iodine-131 and caesium-137 deposition on the ground for the Fukushima Daiichi accident. Since there were no criteria for use in long-term protective actions in the NSC guide, the revised recommendations of ICRP Publications 103, 109 and 111 have been taken into consideration for determining the temporary relocation of the inhabitants in the heavily contaminated areas.

On April 22, the areas outside 20 km from the site where annual cumulative dose for the inhabitants would potentially reach 20 mSv were set to be “deliberate evacuation area”, taking into consideration of the lowest end of the reference level in the emergency exposure situation. The inhabitants in the deliberate evacuation areas were asked to leave by the end of May. At the same time, the rest of the sheltering area between 20 to 30 km radius from the site was renamed to “evacuation-prepared areas in case of emergency” where the inhabitants need to be always prepared themselves for sheltering or evacuation in case of further emergency. In addition, hot spots with dose above 20 mSv per year were identified and set as the “specific spots recommended for evacuation” on June 16. The inhabitants in these spots did not have to evacuate immediately but they had to be cautious about daily life not to exceed 20 mSv.

The new criterion of annual dose of 20 mSv was used rather as an intervention level for justifying temporary relocation than as a reference level during implementation of the optimisation process for exposures in emergency exposure situations. During the discussion of implementing temporary relocation, there was another issue raised related to the criteria whether the playground contaminated can be used for children in April.

MEXT selected 20 mSv/y of the dose band for existing exposure situation recommended by the ICRP. This was because the ICRP Publication described that the transition from an emergency exposure situation to an existing exposure situation may take place at different geographical locations at different times, such that some areas are managed as an emergency exposure situation whilst others are managed as an existing exposure situation. This level was selected as a starting point for optimisation and MEXT later advised the prefecture to reduce the dose to 1 mSv/y, but the selection of the same value as for relocation case raised social concern.

Conclusions

A general lesson learned from the Fukushima accident as well as the accidents of TMI and Chernobyl is that there was an implicit assumption that such severe accidents could not happen and thus enough attention had not been paid to preparedness for the accidents by the operators and the regulatory authorities. Although arrangements for the preparedness and response for severe nuclear accidents in Japan have not been well in place at the onset of the Fukushima accident, the former recommendations described in ICRP Publications 60 and 63, and new recommendations in Publications 103, 109 and 111 have been very helpful and useful for taking emergency protective actions at the early stage of the accident.

Among several initial lessons learned from the Fukushima accident, it is particularly suggested that arrangements should be established for taking precautionary urgent protective actions before a release on the basis of plant conditions. Also international guidance should be developed for the application of operational criteria for use during the emergency response phase.

The following suggestions are identified for improving emergency preparedness and response at the early stage of the accidents:

- to make practical recommendations for control of contaminated foodstuffs and water, and
- to clarify the intended use of the concept of dose limits, constrains and reference levels for protection of the public.

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ANNEX-3

WPNEM Programme

The NEA has a long tradition of expertise in the area of nuclear emergency policy, planning, preparedness and management. Through its technical programmes, the NEA offers its member countries unbiased assistance in the nuclear preparedness arena, with a view towards facilitating improvements in nuclear emergency preparedness strategies and nuclear emergency response at the international level, with a particular focus on decision-making, international communication, information exchange and the compatibility of response actions between various countries.

The mission of the CRPPH Working Party on Nuclear Emergency Matters (WPNEM) is to improve nuclear emergency management systems within member states, and to share its knowledge and experience widely. Within this framework, WPNEM activities focus on identified needs in planning, preparedness and response for the "early" and "intermediate" phases of a nuclear/radiological emergency (including accidents and consequence management for malicious acts), with a view towards preparation of recovery actions. The programme of work is developed in co-ordination with member states and other international organisations.

A view of the emergency management timeline and emergency phases.

Preparedness	*Response*				*Recovery*
	Early		*Intermediate*		*Late*
Planning Stage	Event / Response Initiation	Crisis Management	Consequence Management	Transition to Recovery (including recovery planning)	Recovery / Long-term Rehabilitation
	Emergency exposure situation				Existing exposure situation

Participants are emergency management experts from OECD/NEA countries with recognised knowledge, skills and abilities in the nuclear field. The Working Party employs a flexible approach to address issues across the entire spectrum of nuclear and radiological emergency management, from preparedness to transition to recovery. Participants share information, data, knowledge, and experience to test all aspects of emergency management systems and approaches, identify gaps and provide recommended strategies to improve nuclear emergency management worldwide.

From the beginning, the NEAs focus of work as carried out by the WPNEM has been on improving the effectiveness of international nuclear emergency preparedness and management. Part of its work programme focuses on exploring and developing new concepts and future procedures to enhance national and international preparedness and response management. A key aspect of these efforts has centred on preparing, conducting and evaluating the International Nuclear Emergency Exercise (INEX) series, which has been organised by the WPNEM since 1993. The experiences and lessons learned from these exercises have provided a substantial base for the development of subsequent strategies and recommendations for improving emergency management systems nationally and internationally.

The WPNEM has recently completed the process of evaluation of the INEX 4 exercise on consequence management and the transition to recovery.

ANNEX-4

WPNEM Expert Group on the Implementation of New International Recommendations for Emergency Exposure Situations (EGIRES)

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