ENISS
European Nuclear Installation Safety Standards

Position Paper

European Nuclear Power Plant Licensees' position to support the development of On-Site and Off-Site Emergency Preparedness and Response arrangements proportionate to risk

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CONTENTS

SUMMARY

ENISS and its member organisations are obligated through national regulation to both prevent and respond to accidents and are therefore in a unique position to understand the balance in implementing international nuclear safety standards and management of the consequences of nuclear & radiation accidents. As Nuclear Power Plant (NPP) accident prevention standards and practices improve to practically eliminate large radiation releases, the absence of a process linking through to the extent of emergency arrangements is becoming increasingly apparent, resulting in disproportionate on and off-site response expectations. This, in turn, leads to damaging public confidence in the nuclear industry when diverse energy sources are required to combat climate change.

All actors in the development of NPP Emergency Preparedness and Response (EP&R) arrangements (operators, regulators, authorities and agencies) are encouraged to consider developing a transparent linkage between deterministic and probabilistic safety analyses to the extent of these arrangements. This would allow emergency arrangements to normalise/reflect the risks associated with NPP operation and exposure to radiation, together with providing a basis for optimising resources appropriately factored with the potential socio-economic impacts at the local and national levels, and do more good than harm.

Industry history teaches us that resilience to extended condition events also needs to be considered in designing proportionate emergency responses. Response to extended condition consequences incorporates the public protection measures advocated for all hazards by local and national authorities. Integrating NPP emergency arrangements with the all-hazard approach would benefit the resource allocation, public awareness of mitigation provision for both non-radiological and very low frequency radiological health concerns.

More operator organisations' input into the development of EP&R international guidance, particularly the revision of GSR Part 7, is essential for wider regulator acceptance of the process for developing emergency arrangements, leading to international harmonisation and ultimately improving public confidence in the future of the nuclear energy option.

1. INTRODUCTION

1.1. A position paper to support the ENISS EP&R statement published in 2023

As part of the ENISS ambition to support practicable safety standards and their harmonised implementation across Europe, ENISS called for a new paradigm to ensure Emergency Preparedness and Response (EP&R) arrangements are effectively proportional to risk, in a statement published in 2023 (see **Appendix**).

ENISS represents operator organisations and is uniquely positioned to implement the guidance relating to Nuclear Power Plants (NPP) safety standards and public protection. In this respect, ENISS members identify inconsistencies/imbalances in guidance interfaces which may not be apparent to the issuing organisations.

The position statement recognises that a disproportionate approach in designing EP&R may be a significant barrier to the development of NPPs. It also recognises the importance of due consideration of the public perception.

The following principles were presented to support a new approach:

- Emergency plans should be clearly linked to an objective assessment of the risks posed by the facility in its environment. A “one-size fits all” model based on consequences only is most unlikely to be successful.
- Emergency plans should not exaggerate the radiation risks posed by the facility, potentially leading to an unbalanced perception of risk among the public or others who might need to take part in accident response, and clearly recognise the importance of non-radiological health impacts and the significance of both prior information and effective communication during an emergency[1].
- Emergency plans should follow an approach that is capable of being applied to a wide range of nuclear power plants, accounting for their respective characteristics (including existing and future designs).
- Emergency plans should embody the IAEA fundamental safety principles in all respects and particularly the requirement that emergency plans should be based on risk and not on maximum theoretical consequences irrespective of likelihood.

This approach should be capable of conveying a more accurate picture of the risk from radiation in the event of a nuclear site emergency, and thus sustaining public confidence.

ENISS members provide a licensees’ perspective of the evolution of the risk profile of the nuclear industry, which is continually reducing from implementation of improvements learnt from operating experience feedback and must be appropriately taken into account when developing EP&R arrangements.

This position paper aims to provide more insight and more detailed principles to support the development of risk-proportionate EP&R arrangements.

Chapter 2 develops the reasons why this is important from the industry point of view.

[1] In contrast, an approach which results in an increase in the scale of EP&R arrangements for existing European nuclear sites but which is not linked to a reassessment of their risk will not only be difficult to explain but will actually tend to undermine public confidence in regulators and the industry. If applied to new European designs this approach will also reduce the potential for their adoption within Europe and beyond.

Chapter 3 summarises the current international standards and guidance.

Chapter 4 brings information on current practices in ENISS members' organisations and countries.

Chapter 5 develops key principles, also accounting for the specifics of new technologies as Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs).

Before going further, it is useful to provide, in the following section, a basic summary of where EP&R arrangements sit in the Defence-in-Depth (DiD) concept.

1.2. Defence-in-Depth Concept and EP&R role

The concept of DiD is indicated as the primary means to achieve nuclear safety in IAEA Fundamental Safety Principle 8 (Prevention of accidents) [1]: *"All practical efforts must be made to prevent and mitigate nuclear or radiation accidents."* Two key elements of DiD are:

- Prevention & Mitigation: prevention of failures, abnormal conditions and accidents, and mitigation of their consequences if they were to happen.
- Different independent layers of protection: If one level of protection or barrier were to fail, the subsequent level or barrier would be available.

IAEA GSR Part 7 [2] defines emergency arrangements as: "The integrated set of infrastructural elements, put in place at the preparedness stage, that are necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiological emergency. These elements may include authorities and responsibilities, organisation, coordination, personnel, plans, procedures, facilities, equipment or training". This definition addresses on-site and off-site arrangements.

The concept of DiD and requirements for implementation of DiD in new NPPs are addressed in IAEA SSR-2/1 (Rev.1) [3], for instance. Five levels of DiD are defined, of which levels 4 and 5 at least infer EP&R arrangements:

- DiD level 4 (as defined by WENRA [5][2]): severe accidents, being accidents involving significant core degradation, are part of DiD level 4. The safety objective in the case of a severe accident is that only protective actions that are limited in terms of length of time and areas of application would be necessary, and that off-site contamination would be avoided or limited. This means that the off-site radiological consequences could necessitate off-site measures such as sheltering and evacuation, however, of limited duration and within a limited zone around the plant site.
- DiD level 5: the purpose of the fifth and final level of DiD is generally viewed as the radiological consequence mitigation in case of significant radioactive releases resulting from accidents. This requires the provision of adequately equipped emergency response facilities, emergency plans and emergency procedures for on-site[3] and off-

[2] Information indicated because of the differences in definition of DiD Level 3 and Level 4 between IAEA and WENRA.

[3] When « on-site » is mentioned it actually means arrangements managed by the operator. It may include support from external (off-site) resources (human and equipment).

site[4] emergency response. The establishment of off-site protective actions are generally presented as belonging to the fifth level of DiD, and requirements regarding such arrangements are established in GSR Part 7 [2].

At DiD level 4, the WENRA objective O3 states that *"event sequences that would lead to an early radioactive release or a large radioactive release are required to be practically eliminated"* [5], with additional clarifications:

- An *'early radioactive release'* is a radioactive release for which off-site protective actions would be necessary but would be unlikely to be fully effective in due time.
- A *'large radioactive release'* is a radioactive release for which off-site protective actions that are limited in terms of lengths of time and areas of application would be insufficient for the protection of people and of the environment.
- The possibility of certain conditions arising may be considered to have been *'practically eliminated'* if it would be physically impossible for the conditions to arise or if these conditions could be considered with a high level of confidence to be extremely unlikely to arise[5].

It is important to avoid too simplistic interpretations of the Defence-in-Depth representations, particularly with regard to emergency arrangements. The position of DiD Level 5 in the usual DiD figures should be seen as an oversimplification because the notion of escalation from DiD Level 4 to Level 5 is not relevant as is the escalation from DiD Level 2 to Level 3 or from DiD Level 3 to Level 4.

The off-site arrangements are deployed under the responsibility of the local and/or national authorities. The measures to be considered for public protection during an NPP accident are the same as for many public emergency situations (sheltering, evacuation). Unique to NPP is the use of stable iodine tablets to block radioactive iodine from uptake to the thyroid gland. The convention for planning the implementation of public protection measures is to use planning distances or zones concentric on the site (e.g. PAZ, UPZ). In practice, off-site emergency arrangements are activated for NPP conditions associated with DiD Level 2 or 3 (or possibly precursors of such conditions). For instance, when the plant conditions are at DiD Level 3, off-site arrangements aim at being prepared for deploying protection means according to prognosis results, potentially leading to anticipate protection instructions, iodine prophylaxis or sheltering for example, or even evacuation if the likelihood of severe accident conditions at short term is high. For plant conditions corresponding to DiD Level 4, predicted radionuclide releases may already have prompted decisions to deploy protective means, while complementary measures may be taken in anticipation of a potential increase in releases.

The on-site EP&R arrangements[6], under the licensee's responsibility, can be associated with different levels of DiD as there are functions and provisions adapted to different plant conditions or levels of severity, for example: protection of the workers on site (e.g. site

[4] « Off-site emergency response » is under the responsibility of the authorities and mainly focuses on the protection of the public.

[5] More discussions and information about practical elimination are developed in the ENISS position paper "Application of the concept of Practical Elimination of scenarios" [13].

[6] On-site emergency arrangements cover the protection of the workers and the implementation of capabilities to deploy means and human resources to prevent escalation to more severe situations and to mitigate the consequences of the accident. This may include resources and capabilities which are not located on the site.

evacuation), interfaces with the authorities, off-site radiation measurements, arrangements which aim at preventing escalation of the event, typically from Level 3 to Level 4, means to support accident management in the short and long terms.

The DiD model with its levels 1 to 4 provides a strong basis for design and operating nuclear installations safety. On-site and off-site emergency arrangements provide additional and independent lines of defence applicable at different levels of plant conditions, as such in compliance with the general Defence-in-Depth principle, but it cannot be simply represented as a Level 5 intended solely to address situations in which Level 4 provisions have failed. Introducing emergency arrangements only at level 5 leads to the simplistic view that all other levels have failed, and the most serious accident conditions would be the start point for EP&R arrangement design. On the contrary, in a proportionate-based EP&R design, emergency actions are performed in plant conditions associated to lower DiD levels.

2. IMPORTANCE OF DEVELOPING RISK PROPORTIONATE EMERGENCY ARRANGEMENTS

This chapter explains why the European Operators claim that proportionality to risk has to be appropriately taken into account when developing and deciding emergency arrangements.

2.1 Current technical position

Nuclear operators and regulators are continually working to reduce and prevent accident situations. Existing operating plants have, over the years, implemented many improvements to safety standards, especially from the Three Mile Island-2 and Chernobyl accident learnings. These changes implemented in Structures, Systems and Components (SSCs), operations processes and safety culture have made accidents and large releases less likely than when NPPs were originally commissioned. Following the Fukushima accident, involving a severe plant failure and release of radiation, no deterministic radiation effects on or off-site were observed. Even so, NPPs implemented additional safety features, strengthening the DiD levels. These safety features resulted from advances in safety standards, relevant good practice and technology implemented through international guidance.

EP&R capability scope of response and resilience became increasingly important and a topical issue with significant changes introduced through new international guidance and implemented by operators and state agencies for Fukushima-type events

Despite the reduction in risk of accidents, the basis of the international guidance for emergency arrangements has basically remained unchanged. In addition, differences between some post-Fukushima national decisions regarding the extent of the EP&R arrangements (e.g. increasing the size of the Emergency Planning Zone) may be difficult to interpret.

If continually applied to new designs which “practically eliminate” large releases through safety improvements, a “one size fits all” approach or uniform EP&R assumptions applied to all designs, may result in disproportionate conservatism and hinder new technology adoption.

It is then key to establish EP&R standards and guidance fully consistent with the design and operations safety standards. This would reflect the safety improvements made in current operating NPPs, accommodate future designs and allow changes with the lifecycle risk changes.

A defined technical process for providing the scope and extent of emergency arrangements would allow better alignment and comparison between countries and reactor types. The resulting EP&R guidance would support harmonisation within Europe.

2.2 Public acceptance

Off-site emergency arrangements constitute a key interface between nuclear safety and the public and therefore play a key role in shaping public perception of nuclear power plant safety.

It is fundamental to properly justify the emergency response arrangements to support the operators and the authorities in their training and for them to set up realistic exercises enabling effective experience feedback and lessons learnt, but also to support public acceptance. The aim will always be to minimise overall harm through optimising the response capability. The spectrum of potential accidents needs to be analysed and compared with risk tolerance to ensure the preparation is capable and acceptable. It is important to avoid contradictory actions or explanations causing doubts (e.g. claiming to increase safety level by design whilst EPZ increases too). With the resurgence of nuclear energy as a reliable power source, also contributing to combat climate change, the public has regained confidence, and it is important to improve or maintain a realistic perception of risk by the public. An approach which increases the scale of emergency plans for existing or new European nuclear sites or is based on “one size fits all”, which is not linked to an assessment of risk, will not only be difficult to explain but is likely to undermine public confidence in regulators and the industry.

2.3 Justifiable EP&R related resources

The costs of the EP&R arrangements for the operators are significant and tend to continually increase.

In practice, it is recognised that the financial contribution in EP&R needs to be considered against investment in accident prevention/mitigation and plant enhancement programmes, accounting for proportionality to risk.

Costs for the involved authorities should also be appropriately factored with their potential socio-economic impacts at the local and national levels.

2.4 Predictability of licensing

The emergency arrangements under the responsibility of the operator are part of the elements which are assessed in the frame of the licensing for a new build project or along the site lifecycle, including Long Term Operation (LTO), i.e. Lifetime Extension.

Adopting a common approach for designing proportionate EP&R arrangements would support stability, practicability and effectiveness of the regulatory frameworks, and thus the predictability of licensing.

3. INTERNATIONAL EP&R GUIDANCE

The international guidance review was primarily focused on IAEA safety standards as the fundamental basis for the EP&R practice adopted across Europe and the rest of the world. The IAEA requirements and guidance are used as key references in OSART and EPREV missions, giving a significant prescriptive impact similar to regulation, even though not mandatory for Member States.

Numerous international organisations and agencies sponsor the IAEA EP&R guidance and produce additional guidance. It is assumed that the IAEA documentation consolidates the specialist information developed by these organisations and agencies.

A consistent theme for preparation of emergency arrangements in the lead IAEA documentation [1] and WENRA Safety Reference Levels (Issue R) [11] imply the response should be designed to be proportionate to the risk. However, GSR Part 7 introduces the threat categories, positioning all NPPs in threat category 1 (because only based on power output), which leads to specified requirements of the extent and capability of emergency arrangements, irrespective of design and site characteristics. The future revision of GSR Part 7 should eliminate this misalignment with the principle of accounting for actual risk proportionality. It could appropriately consider EP&R arrangements to be designed on the mitigations to be taken following an accident to achieve an exposure objective and allow facilities to be categorised within the threat table based on an agreed accident consequence assessment methodology. Concurrently, the future revision of GSR Part 7 should also clarify how safety assessments that demonstrate the practical elimination of early or large releases are to influence the assignment of emergency preparedness categories and the corresponding scaling of emergency planning zones and response capabilities.

4. CURRENT EP&R DEVELOPMENT PRACTICES IN THE ENISS MEMBERS' ORGANISATIONS AND COUNTRIES

Information was gathered through a survey amongst ENISS members to establish the basis of current operator EP&R development practice & outcomes.

Based on the answers to the survey, ENISS members' feedback has been summarised as follows:

- The development of the regulatory frameworks for managing operator and local agency EP&R arrangements was established before the IAEA EP&R requirements and guidance were produced early 2000's. From the IAEA point of view, GSR Part 7 [2] should form the basis for member state regulation. However, in ENISS members' countries, regulatory frameworks have developed somewhat independently from IAEA GSR Part 7 and then remain quite independent from GSR Part 7, ENISS members' countries use other international guidance, such as the HERCA-WENRA approach [6].
- None of the ENISS members recognise the potential for deterministic radiation effects as a criterion to categorise the basis for developing emergency arrangements.
- The application of a common accident consequence assessment procedure could provide the framework to grade NPP facilities.

- Operating organisations have a wide scope of emergency response capabilities to address radiation & nuclear emergencies, but also other risks like security threats and release of toxic substances, accessibility for workers involved in the emergency response, where additional practices and guidance exist promoting proportionate design for EP&R arrangements to reduce harm. GSR part 7 does not suggest a comparable response basis for these risks.
- ENISS members use analysis methods and results of different types of safety assessments as the basis for EP&R arrangements. Typically, the EP&R arrangements are based on the technical assessment and risk evaluation of NPP accidents and on national regulations.
- IAEA documentation (e.g. EP&R series, safety guides) is typically used as supporting guidance or references to the state and operators' response capabilities.
- The approach for determining the EPZ is country dependent. In some countries, EPZ would be determined only by the authorities, while in other countries, EPZ could be proposed by the licensee to the authorities for final approval. The requirements and guidance and the application of international recommendations, e.g. IAEA guidelines on how to determine EPZ, are strongly dependent on the country. This could result in very different EPZ distances for the same nuclear facility depending on the country where it would be built.
- ENISS members stress the need for a higher degree of operator input into the development of EP&R international guidance for existing NPPs and to enable operation of new designs.

5. EVOLUTIONS NEEDED IN THE EP&R STANDARDS

5.1 Introduction

In addition to extending the lifetime of NPPs currently in operation, the nuclear sector is considering new build programmes for delivering future energy needs with existing Generation III and new designs, including innovative technologies. These new designs and current operations now incorporate improvements which reduce the risk of accidents and their consequences. The future basis for EP&R should be considered in the context of current and future risk assessments and move on from the guidance developed following past nuclear accidents.

Most of the evolutions to be considered in the EP&R standards should apply to all NPPs:

- Generation II NPPs, which have undergone significant safety improvements since their commissioning (including in the frame of Long-Term Operation or Lifetime Extension projects).
- Large Generation III NPPs.
- New technology NPPs, e.g. SMRs/AMRs, Gen.IV.

This latter case deserves specific considerations, which are presented in Section 5.2. Then, the key principles to successfully develop EP&R arrangements proportionate to risk are developed in Section 5.3.

5.2 SMR/AMR case

The topic of Emergency Planning Zones (EPZ) has been one of the first issues looked at by the SMR Regulators' Forum [7]. One of the conclusions states that "*SMRs encompass a variety of nuclear power plant designs*" and that "*there is a need to consider that the EPZ for SMRs is scalable depending on the results of a hazard assessment, the technology, novel features and specific design criteria, as well as for some, policy factors*". It is also acknowledged that "*the same design of SMR implemented in different countries may result in different EPZ size depending on the regulation, protection strategy, dose criteria, policy factors, and public acceptance*". It is also highlighted that "*existing IAEA Safety Standards already address EPZ*" and that "*according to existing IAEA Safety Standards, it would not be appropriate to consider EPZ* and distances as a design requirement (they are neither defined or determined in/by the design)" [3].

INSAG-28 [9] states: "*The practical implementation of the fifth level of defence in depth should depend on the results of a plant specific hazard assessment. With regard to the fifth level of defence in depth, the lack of an internationally harmonized approach to the determination of emergency planning zones and associated requirements complicates this assessment. Harmonisation and internationally agreed practices would be useful in terms of the source term assessment, dose criteria and determination of emergency planning zones, and other emergency preparedness arrangements. This would entail the review of the use of prescriptive approaches, which have been the traditional basis for regulatory appraisals in the past.*"

Hence, EP&R considerations for new designs can be illustrated for the SMR case study along the following axes:

- Importance of a graded approach for EP&R
- Relationship between EP&R and the design process
- The need for harmonisation of EP&R approaches

<u>Importance of a graded approach for EP&R</u>

As presented in Chapter 3, the graded approach principle is mentioned at the highest level of IAEA Safety Standards.

EPZ may not always be based on a graded approach: fixed distance EPZ could be imposed independent of the risk presented by the specific nuclear facility. This is not suitable for SMRs encompassing a variety of designs having different risk profiles.

For some small modular reactors (SMR) and micro modular reactors (MMR), it could be a design objective that the potential radiological consequences are such that the authorities could decide for an EPZ not beyond the site limit. Such an objective would be in line with a potential siting closer to other industrial sites or densely populated areas, e.g. for cogeneration purposes or for district heating, necessitating being located near the end users to avoid heat transfer losses. Being able to demonstrate such an objective would also contribute to improving public acceptance, as the message could then be that no credible accident would lead to the need for off-site measures.

As presented in Chapter 3, even though the application of a graded approach is promoted, the categorisation seems to indicate that all Nuclear Power Plants have to be considered as emergency preparedness category I facilities, which goes against the principle of the graded approach.

IAEA Safety Standards give no clear guidance on how far one needs to go in the scenarios to be considered to determine the EPZ. It is specified that on-site events should be considered, including nuclear security events, as well as events not considered in the design. It is further specified that 'this includes events that are beyond the design basis accidents and, as appropriate, conditions that are beyond design extension conditions. As 'beyond design extension conditions' seem to indicate very low frequency-high severity events, it could be expected that rare and severe external hazards are important contributors to this.

As a result, it will depend on the interpretation/guidance of a specific country on how to apply this in practice, giving rise to very different EPZ distances for the same kind of nuclear installations. This was clearly confirmed in the European report [8], one of the important conclusions being: "*There is large variation (by more than an order of magnitude) in the size of EPZ around nuclear power plants in Europe. This reflects differing judgements between countries as to what it is reasonable to plan for in detail, in particular the choice of accident or scenario (i.e., size and nature of release and the meteorological conditions to be considered) that has been used as the basis for detailed planning and preparedness*". This finding is also stated in INSAG-28 [9].

The country-dependency was also confirmed by the ENISS members, cf. Chapter 4.

As an illustration of the need for scalable EPZ for SMR, the recent regulatory evolution in the USA can be taken as an example, is given in [10].

Relationship between EP&R and the design process

Historically, it has not been considered appropriate to include emergency planning zones and distances as a design requirement, and it does not seem to be a consideration for the future e.g. in an IAEA presentation on Addressing the issue of EPZ sizing for SMR [4], and also in the SMR Regulator's Forum report [7]. However, it can be noted that several SMR and AMR designers claim a design objective that the EPZ is not beyond site limit. This represents an apparent difference of viewpoints where clarification is needed to ensure that all parties (designers, licensees, authorities) clearly understand their responsibilities and what is expected from them.

The need for harmonisation of EP&R approaches

For SMR/AMR designs to be economically viable, it is absolutely necessary that the same standard design be replicated (also contributing to enhanced safety), and that this design be accepted for construction and operation in similar environments, such as densely populated areas, uniformly across Europe and wider. This is a key condition to favour the emergence of the construction of a large series of identical designs. The acceptance criteria are linked to the safety assessment and also to the feasibility and acceptability of emergency arrangements, implying interactions with the public (in practice, this principle would also apply to large reactor designs).

This linkage is important to avoid unexplainable discrepancies between emergency arrangements applied for similar sites in different countries, as well as a higher level of harmonisation between European countries regarding requirements, interpretation, and guidance on how to determine the EP&R arrangements, including the EPZ.

5.3 Key Principles and Recommendations

Key principles and recommendations are proposed to successfully support the development of emergency arrangements proportional to risk for existing and future nuclear facilities.

Use of the Deterministic and Probabilistic Safety Analyses

A common and holistic background should be considered for justifying the adequate protection of the public, with the following contributions:

- NPP safety performance, under the licensee's responsibility (evaluated through the NPP safety case).
- On-site emergency arrangements, under the licensee's responsibility.
- Off-site emergency arrangements, under the Authorities' responsibility.

Designing the emergency arrangements on the technical assessments from the safety case process, and thus a meaningful linkage to the DiD concept, should provide the basis for ensuring the resources allocated to emergency response are optimised and proportionate to the likelihood and consequences of accidents.

Guidance could be developed with good practices in using deterministic and probabilistic safety analyses for the purpose of designing EP&R arrangements.

Resilience objectives for EP&R response

Not all accidents can be prevented, and when this is the case, an effective line of defense on the plant is the emergency arrangements that can support the prevention of escalation to a more severe situation and radiation exposure. When designing these emergency arrangements, "to do the most may do the least" is not the right way of thinking: oversizing provisions and organisations leads to unnecessary technical and human resources, and increased complexity with a lot of interfaces, which may jeopardise the effective accident management.

A relevant response during an emergency is not only a matter of accumulating more and more on-site features, and possibly off-site support, but is also based on the capacity to enhance the resilience of the socio-technical system by preparing the operator's staff to accept and face the "unexpected". At the beginning of an accident (i.e. a short time after the initiating event), no one can foresee the exact development of the accident scenario: additional problems may arise, the credible ones having been thought in advance, others not. The capabilities available can be combined with each other to form a relevant response to the possible scenarios. Commensurate capabilities and agility to combine them constitute an efficient set of operator's emergency arrangements to avoid or limit offsite releases.

Commensurate capabilities designed around likelihood and the agility to combine or extend for more unlikely events constitute an efficient set of emergency arrangements to avoid or limit harm. It is then recommended to set and apply resilience objectives when designing emergency arrangements effectively. Typical associated provisions are: adaptability of technical means, training, exercises, …

This principle should also apply to off-site arrangements.

Roles and duties in the determination of EP&R arrangements, including the EPZ

The determination of EPZ and off-site emergency arrangements is under the responsibility of the Authorities (it may be based on the licensee's or future licensee's proposals), and they depend on the NPP safety performance, the site and site vicinity characteristics and means/actions feasibility/efficiency to adequately protect the population and the environment.

Consistent with qualitative objectives in terms of radiological consequences and emergency actions, e.g. the current WENRA safety objective O3 [5], NPP safety performance implies key design requirements that directly relate to dose limits. It is, however, suggested that the EPZ and associated distances, as such, should not be included as a design requirement. However, a designer or the future licensee may argue on emergency arrangement needs on the basis of the safety analysis results, deterministic and probabilistic. This could encompass the need for an EPZ and its potential size, but it should be kept in mind that many other factors could weigh in on the associated Authorities' decision-making.

Regulatory acceptance criteria for public protection and link to siting purposes

If the public is adequately protected from consequences arising from accident sequences which cannot be practically eliminated, then it can be argued that the plant is safe enough. In practice, to fulfill this condition, a number of aspects have to be considered, and care must be taken when addressing general safety objectives applied to a design:

- reasonableness should be the main driver when considering the responsibilities (licensee's and authorities' parts), whether the details are more or less included in the legislation. An underlying assumption is that the justification of practice is the State's responsibility, with siting conditions which might be more or less detailed,
- uncertainties have to be taken into account appropriately (e.g. in the acceptance criteria),
- an integrated risk-informed decision-making process should be applied (including for setting the acceptance criteria),
- Plant safety objectives or acceptance criteria, especially in terms of accident consequences, are expected to be dependent on the site characteristics, accounting for feasibility conditions and the actual capabilities to protect the public at a reasonable cost. In WENRA safety objective O3 [5], this is qualitatively described as "limited protective measures in area and time [...] with sufficient time available to implement these measures".

International harmonisation needs

As explained in section 5.2 above, more harmonisation is needed to enable the same designs to be built in different countries with similar EP&R arrangements for comparable sites in terms of risks to the public. This applies to SMRs/AMRs as well as to mid-size and large size reactors.

Below is a preliminary list of harmonisation needs directly relating to the determination of the EP&R arrangements, including the EPZ:

- Reference accident sequences and associated justifications e.g. deterministic and probabilistic.
- Radiological consequence calculation methodology (e.g. study rules to be applied, release dispersion modelling, meteorological conditions to be considered).
- Radiological objectives associated with the specific EPZ.
- Effective assessment of the EP&R arrangements.

Consideration of an all-hazard approach (off-site arrangements)

NPP hazard-specific measures would be best placed in the site-related emergency plans to provide the best benefit, and for less frequent events, the protection measures could be supported through the existing all-hazards contingency plan.

When designing the emergency arrangements dedicated to the protection against the radiological risks, the linkage to an all-hazard approach should be adopted to support a risk proportionate decision-making through the practical consideration of protective measures against other hazards (e.g. extreme natural events).

Do more good than harm and public acceptance

The population protection actions as decided and conducted during the Fukushima-Daiichi accident have shown that direct radiation impacts may not be the most important public health consequences from nuclear accidents.

As in previous accidents (Three Mile Island-2, Chernobyl), stress, stigma and the unintended health effects caused by an inappropriate reaction to the accident were responsible at Fukushima for more numerous and arguably much more serious health impacts than those caused directly by radiation exposure [12].

Consistent with GSR Part 7, which defines protection goals as avoiding severe deterministic effects and reducing stochastic and non-radiological consequences, this is a clear lesson learnt which has to be taken into account in the decision-making processes where radiological and non-radiological risks associated with the protection actions have to be appropriately taken into account. Generally, this has been considered in updates of the national and local response plans in Europe.

Confusing and changing communications on “safe” radiation levels resulted in many among the Japanese public losing trust in just those organisations and officials whose job was to give them advice. This not only damaged the short-term response to the accident and led to unnecessary health effects (including fatalities), but it has also remained a significant problem in the recovery phase.

The scale of this problem was not linked to the magnitude of the release but to the public perception of the threat. If Europe ignores this lesson, we could face the same, or even worse, problems in the event of an off-site emergency, even if its scale was far smaller than Fukushima.

Key elements to be addressed to support public acceptance:

- Taking more account of the non-radiological health impacts in emergency planning and in prior information to the public.
- Ensuring that the messages we all provide about the radiation health risks from nuclear emergencies are not exaggerated and do not lead to an unbalanced perception of risk among the public or others who might need to take part in accident response.
- Working with health professionals and the radiation protection community (e.g. ICRP) to ensure that the way in which the international system of radiation protection is set down takes into account public perception and is not only comprehensible to experts. This should include a clearer rationale for the difference in radiation limits for workers and the public, and in existing, planned and emergency exposure conditions.

- Justification of emergency preparedness and response arrangements appropriately communicated to the public, and avoid contradictory actions or explanations causing doubts (e.g. claiming to increase safety level by design whilst EPZ increases too).
- Engaging with the public, create and maintain conditions by which the public is effectively prepared, and feels prepared, to the unlikely occurrence of a radioactive release.

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ABBREVIATIONS

AMR	Advanced Modular Reactor
DiD	Defence in Depth
EP&R	Emergency Preparedness and Response
EPREV	Emergency Preparedness Review Service (IAEA)
EPZ	Emergency Planning Zone
GSR	General Safety Requirements (IAEA standards)
HERCA	Heads of European Radiological protection Competent Authorities
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
LTE	LifeTime Extension
LTO	Long Term Operation
MMR	Micro Modular Reactors
NPP	Nuclear Power Plant
OSART	Operational Safety Assessment Review Team (IAEA)
PAZ	Precautionary Action Zone
SMR	Small Modular Reactor
SSC	Structures, Systems and Components
TEDE	Total Effective Dose Equivalent
UPZ	Urgent Protective action planning Zone
WENRA	Western European Nuclear Regulators Association

APPENDIX – ENISS STATEMENT PUBLISHED IN MARCH 2023

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ENISS call for a new paradigm for Emergency Preparedness and Response (EP&R) arrangements to be proportional to risk

Nuclear safety is achieved through the combination of a number of consecutive and independent levels of protection known as the principle of Defence in Depth (DiD). The DiD principle requires that if one level or barrier of protection were to fail, the subsequent level or barrier would be available. The final 5th DiD barrier to protect people and the environment from the harmful effects of ionising radiation is the emergency response arrangements.

The Chernobyl and Fukushima nuclear accidents caused numerous evolutions in nuclear safety standards, resulting in the enhancement of Nuclear Power Plant (NPP) safety at DiD levels 1 to 4 to further reduce the likelihood of accidents involving the release of significant quantities of radiation for operating NPPs (Generation II).

The improved safety design principles lead to a significant reduction in the risks of releases of radiation for new designs (Generation III reactors, including SMRs), eliminating postulated severe deterministic effects on and off-site, the basis for IAEA emergency response categorisation.

ENISS members share the view that the basis of EP&R guidance for NPP radiation emergency needs to be reviewed, as the risk profile of the existing Nuclear Power Plants (NPP) has significantly changed over the years since Chernobyl, and especially since the Fukushima-Daichi accident, and many first-generation reactors, without containment, have entered the decommissioning phase.

For the emerging global demands for energy and the climate crisis requiring zero-carbon generation, nuclear reactors can make a significant contribution to achieving the projected targets. The need for social and economic global survival also suggests that the risk perception and benefits associated with nuclear energy should be revised.

Maintaining a disproportionate approach to risk in the guidance for Emergency Preparedness and Response (EP&R) results in a number of adverse consequences which lead to significant barriers to the development of NPPs as part of the solution against climate change, e.g. misrepresentation of actual risks, lack of consistency, oversized means implying unnecessary resources and complexity.

ENISS seeks an opportunity to engage in discussions on the development of EP&R guidance that supports the DiD and aligns with current Safety Standards, promotes proportionate planning to risks of releases and is consistent with wider national emergency / contingency planning.

It is suggested the principles within such an approach include:

- plans that are clearly linked to an objective assessment of the risks posed by the facility in its environment. A "one-size fits all" approach for NPP's is most unlikely to be successful.
- plans that do not exaggerate the radiation risks posed by the facility (potentially leading to unbalanced perception of risk among the public or others who might need to take part in accident response), but which do clearly recognise the importance of non-radiological health impacts[1] and the significance of both prior information and effective communication during an emergency[2].

The outcome should be a European (and ideally a worldwide) approach that is capable of sustaining public confidence and which at the same time conveys a more accurate picture of the risk from radiation in the event of a nuclear site emergency.

- plans following an approach that is capable of being applied to a wide range of nuclear facilities – i.e. that addresses the characteristics of both existing and future designs of power stations.
- plans that embody the IAEA fundamental safety principles in all respects and particularly the requirement that emergency plans should be based on risk and not on maximum theoretical consequences, irrespective of likelihood.

Furthermore, collaboration between health professionals and the radiation protection community should be fostered to ensure that the way in which the international system of radiation protection is set down takes into account public perception and is not just comprehensible to experts. This should include a clearer rationale for the difference in radiation limits for workers and the public and in "normal", "emergency" and "existing exposure" conditions.

Footnote 1: In our view one area of Fukushima learning that still needs further work is the clear lesson that direct radiation impacts are not the most important public health consequences from nuclear accidents. This is not a new finding but it is one that the nuclear community has still not adequately addressed despite the experience from Three Mile Island and Chernobyl. As in those previous accidents, stress, stigma and the unintended health effects caused by an inappropriate reaction to the accident were responsible at Fukushima for more numerous and arguably much more serious health impacts than those caused directly by radiation exposure. And the scale of this problem was not linked to the magnitude of the release but to the public's perception of the threat. If Europe ignores this lesson, we could face the same, or even worse, problems in the event of an off-site emergency even if its scale was far smaller than Fukushima.

Footnote 2: In contrast, an approach which results in an increase in the scale of EP&R arrangements for existing European nuclear sites but which is not linked to a reassessment of their risk will not only be difficult to explain but will actually tend to undermine public confidence in regulators and the industry. And if applied to new European designs this approach will also reduce the potential for their adoption within Europe and beyond.