Western European
WENRA
Nuclear Regulators Association

WENRA Guidance

Article 8a of the EU Nuclear Safety Directive:

"Timely Implementation of Reasonably Practicable Safety Improvements to Existing Nuclear Power Plants"

Report of the Ad-hoc group to WENRA
13 June 2017

Objective

Production of a WENRA guidance paper on the EU Nuclear Safety Directive Article 8a requirement for "timely implementation of reasonably practicable safety improvements to existing nuclear installations". The guidance has been written specifically with Nuclear Power plants (NPPs) as a focus, but many of the principles should be equally applicable to other types of nuclear installation.

Background

- ENSREG invited WENRA to provide guidance on Art 8a of the Nuclear Safety Directive - "timely implementation of reasonably practicable safety improvements to existing nuclear power plants".
- Timescale to be consistent with the implementation time table for the Nuclear Safety Directive (August 2017).
- WENRA spring meeting decision made to establish an ad-hoc group to develop guidance.
- UK agreed to Chair the group and Finland, Germany, France, Hungary and Switzerland agreed to be members.

Membership of Ad-Hoc Group:

- UK: Mr D M Senior (Chair), Mr G Grint, Mr S Turner, Mr S Harrison
- Hungary: Mr F Lóránd
- Finland: Ms. K Alm-Lytz
- France: Mr J Collet
- Germany: Mr S Kuhn
- Switzerland: Mr N Cordua
- WENRA Secretariat: Ms. G Stoppa

Schedule

- First meeting of ad-hoc group – London 7th July 2016
- Second meeting of ad-hoc group –London 8th September 2016
- Third meeting of ad-hoc group - IAEA General Conference, Vienna – 29th Sept 2016
- First Draft of Guidance Document presented for consideration/discussion at WENRA 'Fall' Meeting in Rome 26th - 27th Oct 2016
- Update to ENSREG Plenary Meeting 3rd November 2016
- WENRA, ENSREG and European Commission review and comment completed 18th January 2017
- Presentation of Guidance to European Commission NSD workshop – Luxembourg 9th March 2017
- ENISS review and comment completed 17th March 2017
- Final Draft of Guidance Document for consideration/discussion at WENRA Spring Meeting 26th /27th April 2017
- Silent Procedure for final approval by 2nd June 2017.
- Final Draft to ENSREG Plenary Meeting 28th/29th June 2017

1. Nuclear Safety Directive - Article 8a

Article 8a (1) - Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding:

a) early radioactive releases that would require off site emergency measures but with insufficient time to implement them;

b) large radioactive releases that would require protective measures that could not be limited in area or time.

Article 8a (2) - Member States shall ensure that the national frameworks require the objectives set out in paragraph 8a (1):

a) applies to nuclear installations for which a construction licence is granted for the first time after 14 August 2014;

b) Is used a as a reference for the **timely implementation of reasonably practicable safety improvements to existing nuclear installations**, including in the framework of the periodic safety reviews as defined in Article 8c(b)

Paragraph (19) of the amending Directive to the Nuclear Safety Directive indicates that "reasonably practicable" as used in the NSD, should be applied in accordance with established definitions, in particular the WENRA and IAEA definitions.

This report provides background and guidance (section 5 and 6) to WENRA members on a common approach to inform their own national frameworks in terms of "timely implementation of reasonably practicable improvements to existing nuclear installations".

2. WENRA interpretation of "reasonably practicable"

The requirements set out in Article 8a (1) are based on WENRA's objective O3 for new nuclear reactors (ref 1). In its companion report (ref 2) for the new reactor objectives, WENRA described reasonably practicable and reasonably achievable as follows:

"Within the WENRA Safety Objectives for New Nuclear Power Plants the words "reasonably practicable" or "reasonably achievable" are used. In this report the words Reasonably Practicable are used in terms of reducing risk as low as reasonably practicable or improving safety as far as reasonably practicable. The concept of reasonable practicability is directly analogous to the ALARA principle applied in radiological protection, but it is broader in that it applies to all aspects of nuclear safety. In many cases adopting practices recognized as good practices in the nuclear field will be sufficient to show achievement of what is "reasonably practicable". For some design expectations in this report, „reasonable practicability" should be taken to mean that, in addition to meeting the normal requirements of good practice in engineering, further safety or risk reduction measures for the design or operation of the facility should be sought and that these measures should be implemented unless the utility is able to demonstrate that the efforts to implement the proposed measures are grossly disproportionate to the safety benefit they would confer."

At the time of publication of the WENRA reference levels in 2014, there were some concerns about including the precise definition because it was unclear how some of the wording, which was based on interpretation of the law in the UK, could be readily adopted or interpreted in some national legal frameworks. Consequently

the definition above was not formally included in the new reference levels though there was a common understanding in WENRA countries of the meaning of "reasonably practicable" in the reference levels.

3. IAEA interpretation of "reasonably practicable"

The term "reasonably practicable" is used in the IAEA's Vienna declaration (ref 3) and the context in which it is used implies the same understanding as in the WENRA text. However, we could find no explicit definitions in IAEA documentation but the IAEA safety fundamentals SF1 (ref 4) principle 5 on optimization of protection is very close:

> *"The safety measures that are applied to facilities and activities that give rise to radiation risks are considered optimized if they provide the highest level of safety that can reasonably be achieved throughout the lifetime of the facility or activity, without unduly limiting its utilization.*
>
> *To determine whether radiation risks are as low as reasonably achievable, all such risks, whether arising from normal operations or from abnormal or accident conditions, must be assessed (using a graded approach) as a priority and periodically reassessed throughout the lifetime of facilities and activities.*
> *Where there are interdependences between related actions or between their associated risks (e.g. for different stages of the lifetime of facilities and activities, for risks to different groups or for different steps in radioactive waste management), these must also be considered. Account also has to be taken of uncertainties in knowledge.*
>
> *The optimization of protection requires judgements to be made about the relative significance of various factors, including:*
>
> *—The number of people (workers and the public) who may be exposed to radiation;*
> *—The likelihood of their incurring exposures;*
> *—The magnitude and distribution of radiation doses received;*
> *—Radiation risks arising from foreseeable events;*
> *—Economic, social and environmental factors.*
>
> *The optimization of protection also means using good practices and common sense to avoid radiation risks as far as is practical in day to day activities.*
> *The resources devoted to safety by the licensee, and the scope and stringency of regulations and their application, have to be commensurate with the magnitude of the radiation risks and their amenability to control. Regulatory control may not be needed where this is not warranted by the magnitude of the radiation risks. "*

4. Periodic Safety Review and continuous improvement

In all WENRA countries, licensees are expected to perform a periodic safety review (PSR) (ref 5) of their plant at least every ten years. This is an opportunity to review not only the conformity of the plant, but also identify possible safety improvements. Safety improvements can be related to the plant design but also to organizational issues (e.g. management systems and procedures). On the basis of the results of the PSR, regulators generally review the continued acceptability of the continuation of operation of the plant. This does not mean that further improvements should not be considered or implemented between PSRs.

PSR significantly contributes to the continuous improvement of safety. The concept of continuous improvement is illustrated in Figure 1, which is a simplified representation of safety through plant life, and does not for example show the timescales for implementing plant improvements or the effects of aging of plant systems, structures and components.

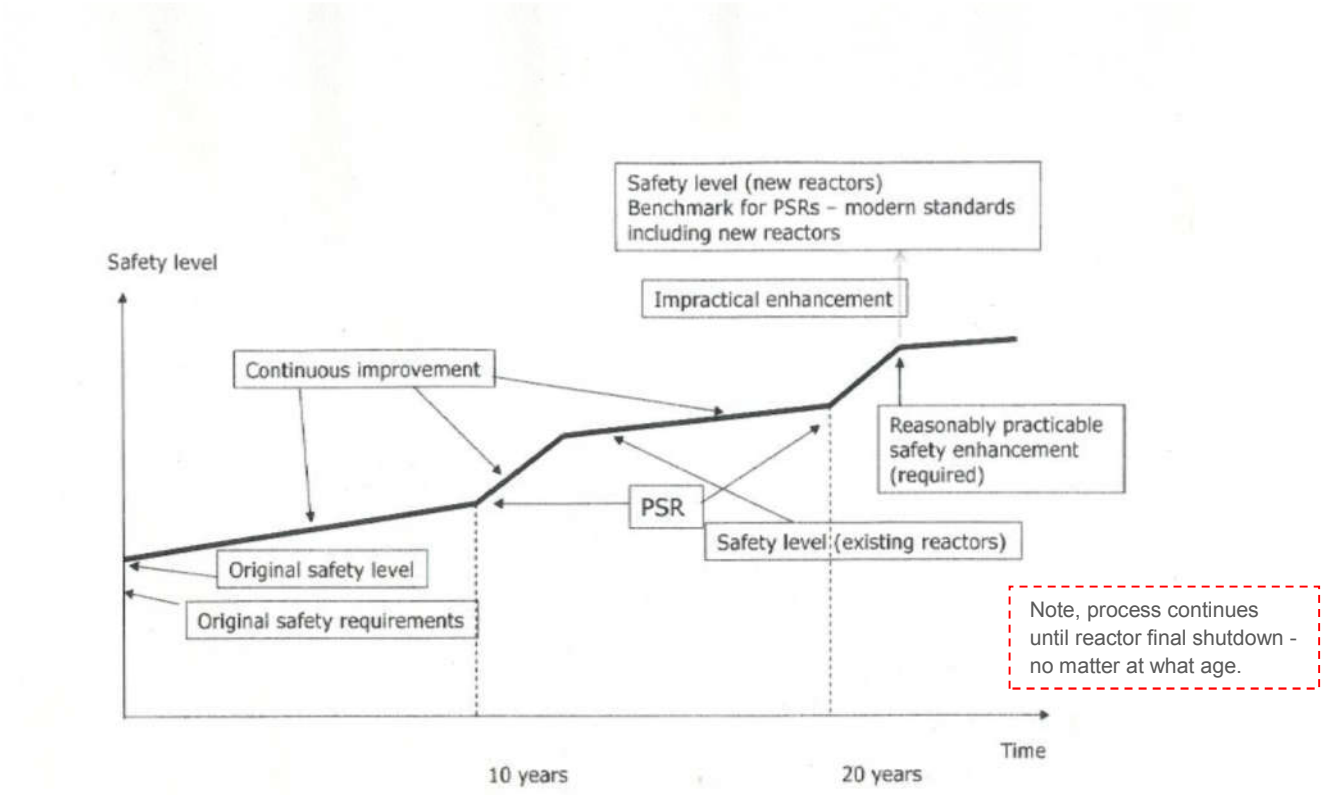

Figure 1 The concept of continuous improvement

When the existing reactors were commissioned, their original safety level met the required safety level based on the safety requirements which were in force then. Safety requirements for NPPs can be updated based on the operating experience and safety research and advances in science and technology. New reactors are designed to meet higher levels of safety than the existing ones. Despite the fact that existing reactors undergo PSRs as a result of which safety enhancements are implemented, it is likely that there will remain a difference between the safety level of oldest and newest reactors. One example is a difference between the severe accident mitigation provisions integrated into the design in new reactors compared to the back-fitting measures in the older reactors. In some cases, it will be reasonably practicable to enhance safety to reach a higher safety level but sometimes further enhancement toward the benchmark is not reasonably practicable.

The need for improvements can also occur anytime between PSRs and significant issues that may put at risk the safety of the plant shall be addressed without delay. Operational experience feedback, particularly related to incidents or events can be important triggers for plant improvements at any time. The safety assessments performed in WENRA countries after the TEPCO Fukushima Dai-ichi NPP accident or the Forsmark NPP event are good examples of actions performed outside the frame of PSRs.

4.1 Conceptual model for reasonably practicable safety improvements

In 2011 WENRA published a pilot study by its Reactor Harmonization Working Group (RHWG) on Long term operation (LTO) of nuclear power plants (ref 6). Although the principle aim of that document was to address issues surrounding plant life extension, the study addressed the role of PSRs and the implementation of reasonable practicable safety enhancements identified during a PSR. As a result the report (ref 6) provides a very good conceptual model for the process of implementing reasonably practicable improvements and, as in the NSD, the LTO report uses new reactor standards as a benchmark for comparison. The diagram from the LTO report is reproduced below together with supporting text which has been amended for the purposes of this current document:

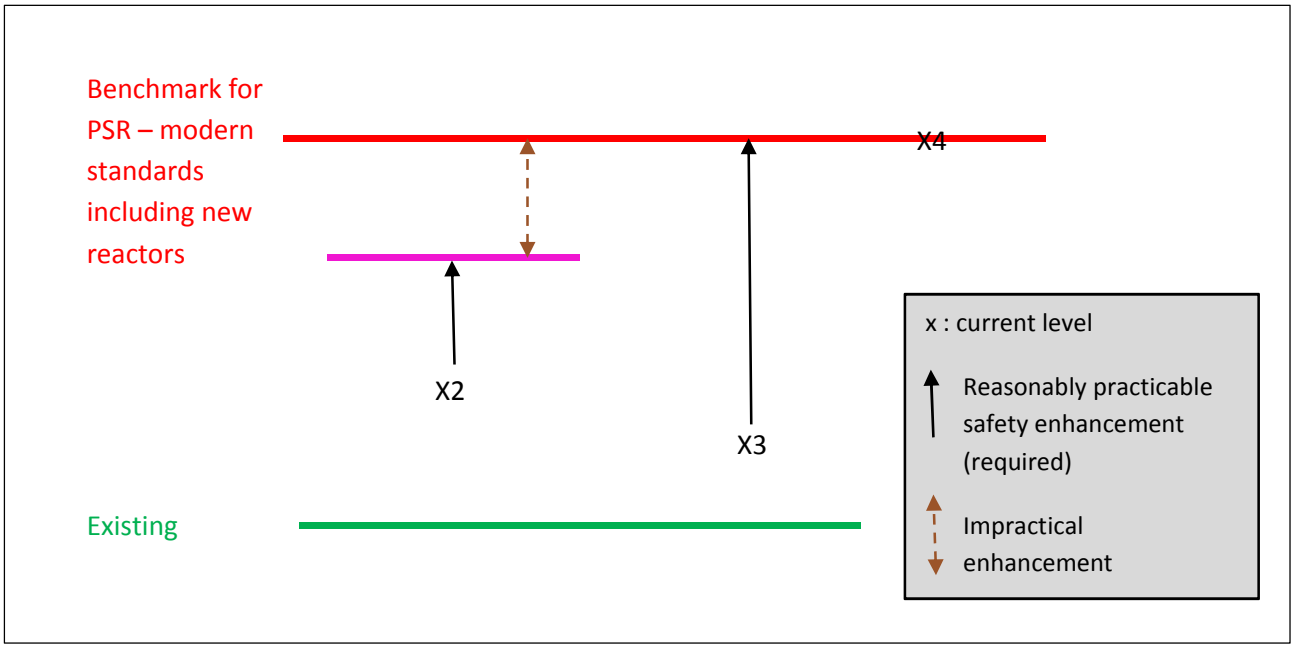

Figure 2 Conceptual model

The above diagram is conceptual and is intended to represent the process of comparing, for a particular feature, existing reactors with modern safety standards in a PSR and, where appropriate, moving towards the higher standard.

As for the horizontal lines:

- The green line represents existing reactor safety standards , and the "X" represent illustrative levels for a variety of safety issue; *For the purposes of NSD article 8a (2), the green line represents current safety standards/levels that should already have been achieved or bettered by existing NPP in WENRA countries.*
- The red line represents modern safety standards, including but not restricted to WENRA's new reactor objectives, and is the benchmark for comparison in a PSR;
- The green and red lines may in some cases be at the same level (e.g. management for safety);
- The space between the green and red line represents the room for safety enhancements to be looked at.

As for the "x":

- Those "X" below red line are safety issues that have to be compared to modern safety standards.

  - In some of these cases it will be reasonably practicable to enhance safety to reach the targets (redline) as in "X3";

  - In some cases, e.g. "X2", it will be reasonable to enhance safety to a level represented by the purple line, but further enhancement toward the benchmark is not reasonably practicable;

  - In other cases there may be no identifiable reasonably practicable options for enhancement;

- The "X4" represents these cases where the existing situation is already meeting the modern safety standard.

4.2 Modern Safety Standards and Practices

The WENRA interpretation of reasonably practicable above means that in many cases adopting modern safety standards and practices (sometimes termed good practices) in the nuclear field will be sufficient to show achievement of what is "reasonably practicable" and discussions between WENRA members confirm that this is generally what is done in practice during PSR. This focus on modern safety standards and practices should remain for compliance with NSD 8a (2) b. For an existing facility, relevant good practice is established by using the safety standards and practices that would be applied to a new design as a benchmark and then subjecting any shortfalls to the test of reasonable practicability. Unless the sacrifice entailed in moving towards the benchmark is clearly demonstrated to be disproportionate to the safety benefit, the licensee should make that move. The larger the shortfall the greater the rigor and confidence needed in the demonstration of disproportion.

Although the main focus is on modern safety standards and practices, the safety analysis report, in particular the probabilistic safety analysis, can be very helpful in identifying the design or operational features of an existing reactor where improvement would provide most benefit and move the level of safety, in terms of preventing or mitigating radioactive releases, closer to the safety standards that would apply to a new reactor.

5. Framework for implementation of "reasonably practicable" improvements

5.1 Consideration of Defence in Depth

Defence in depth is fundamental to nuclear safety. In determining what can be done to further prevent and mitigate radioactive releases the licensees should consider all levels of defence in depth that are within its responsibility (note that in some countries some defences, for example offsite plans, may rest with the authorities). It is also important that measures to enhance the independence between different levels of defence in depth should be part of the consideration of what more could be done to prevent and mitigate radioactive releases. Where improvement measures at a particular defence in depth level are determined to be not reasonably practicable in a particular case, efforts should be made to see if additional improvements in other levels of defence in depth could be considered in their place.

5.2 Role of Probabilistic Safety Analysis

Although WENRA does not have PSA targets in terms of core damage or large release frequency, PSA can still be of great value. The output of a PSA provides some detailed information on the relative strengths and weaknesses of the NPP and therefore is a very useful tool in helping to identify and focus on areas of the plant design and operation where potential improvement will be of greatest safety benefit. The PSA can then be used to help to understand the relative safety benefits of alternative options so that decisions are well informed. A Level 2 PSA is of particular value in identifying where a shortfall exists and assessing potential options for avoiding or reducing the risk of early releases.

5.3 Equivalence of outcomes and proportionality

In comparing safety of an existing NPP with new reactor standards it is important to look at the safety outcome not just the specific technology used to achieve that outcome. The objective is to implement reasonably practicable improvements to prevent and mitigate radioactive releases. There is no standard set, or tick list, of specific engineering or operational improvements that will be appropriate for all reactors and operational regimes, though it is expected that licensees should look at what others have done to prevent and mitigate radioactive releases to see if it is appropriate for them. If those measures are not appropriate they should look at what else they could do to achieve a broadly similar outcome.

Being "proportionate" is a common aim of WENRA members and is a strong element in deciding what is or is not reasonable practicable. A strong feature of being proportionate will be that the greater the shortfall, the more that needs to be done to identify and implement measures to remove or reduce it. Being proportionate

will also mean that certain safety improvements that may be reasonable at one reactor may not be necessary at another or conversely may be insufficient so better or more measures might be called for. Being proportionate should also take account of the individual circumstances of a facility and its future lifetime.

A safety improvement gained by one licensee at a particular defence in depth level may not be reasonably practicable elsewhere for a number of reasons such as: the plant already has more modern provisions and the gap to modern safety standards is less, the design may be less suited to a particular modification or it may be at a different stage in its life whereby that improvement would not deliver a safety benefit for a meaningful period of time (see section on timely implementation above).

5.4 Decision making

The process of deciding what is or is not reasonably practicable is generally iterative between the licensee and the regulator. It is for the licensee to identify the shortfalls in comparison to modern safety standards and to propose measures to improve the shortfall or to justify that there are no reasonably practicable measures in a particular circumstance. The regulator will normally challenge the licensee to demonstrate, with evidence, that:

- All significant shortfalls have been identified
- Options to address the shortfalls have been considered and the safest reasonably practicable option selected
- Where no options are selected they have been shown to be disproportionate with sufficient rigor and confidence

Consideration of the options needs to be carried out in a holistic way taking account of all potential impacts on the safe operation of the plant and include relevant factors such as worker dose in implementing a potential improvement, undue complexity to the plant design or operation, as well as the benefit that an improvement measure has in preventing or mitigating large releases.

As a result of the dialogue it is expected that a set of reasonably practicable improvements will be identified and an appropriate schedule for implementation agreed. The design and implementation of improvement measures should be conducted in line with the normal plant modification procedures and arrangements used by the licensee and regulator.

5.5. Timely implementation of safety improvements.

Time is an important factor in determining reasonably practicable improvements for existing reactors. For example consider a reactor which has a planned closure date of 5 yr. from now but has a shortfall against modern safety standards in its cooling function. Designing, constructing and commissioning a fixed diverse, automatic cooling system may not be the safest option if it takes 4 yr. to become operational. A more modest mobile system, manually operated that can be in place within 6 months that gives a lesser benefit for longer might be the better option. Similarly a more expensive solution that can be implemented earlier, and hence deliver higher levels of safety for longer, may be better than less expensive solution which takes a long time to implement. In the case when the circumstances of the planned improvements are substantially changed (e.g. the intended future lifetime of an existing reactor's lifetime is extended or shortened) the identified reasonably practicable improvements should be reconsidered.

Time is also important if realities such as scheduling and prioritization need to be anticipated. It may not be viable to carry out simultaneous improvements on all of a licensee's reactors due to necessary sharing and reliance on key teams and equipment where it is unreasonable to provide or maintain dedicated resources for each reactor. The limited capacity of suppliers and manufacturers and the need for analysis and testing are also factors in how soon an improvement can be implemented. The licensee may need to take steps to increase capability or expand its supply network. In proposing a schedule for implementation of planned

improvements the licensee should demonstrate that not only are the improvements reasonably practicable, they will be implemented as soon as reasonably practicable, taking due regard of any justified constraints. If long implementation times are unavoidable, the licensees should give consideration to interim or partial measures that could reduce the risk in the meantime. If a reasonably practicable safety improvement measure is not implemented in a "timely" manner the regulatory body has to take further action to enforce the improvement.

5.6 Role of cost.

In some instances licensees may claim that a particular measure is too costly and therefore not reasonably practicable. In some WENRA countries, the regulator may be prepared to listen to such arguments in others the regulator will not take account of costs, though in the event of dispute the courts may take cost into account. Cost Benefit Analysis (CBA) can appear attractive but the uncertainties involved and the assumptions that are a necessary part of a CBA applied to measures aimed at preventing or mitigating large radioactive releases, mean that it must be treated very cautiously. Claims that a licensee simply can't afford a reasonably practicable improvement due to lack of financial resources, even when the costs are reasonable, are not accepted.

6. Conclusions

In the context of NSD Article 8 a (2) b, i.e. where an existing reactor meets the basic design requirements and its operation can be considered "safe", it is suggested that WENRA members share the following understanding of reasonable practicable safety improvements (based on a modified version of WENRA's "New Reactors" terminology):

> ***"The concept of reasonable practicability is directly analogous to the ALARA principle applied in radiological protection, but it is broader in that it applies to all aspects of nuclear safety. In many cases adopting modern standards and practices in the nuclear field will be sufficient to show achievement of what is "reasonably practicable". For existing reactors, where a modern standard or good practice associated with new reactors is not directly applicable, or cannot be fully implemented, alternative safety or risk reduction measures (design and/or operation) to prevent or mitigate radioactive releases should be sought and implemented unless the utility is able to demonstrate that the efforts to implement them are disproportionate to the safety benefit they would confer. The degree of rigour and confidence in the outcome of such a demonstration should take account of nature and scale of the shortfall to modern standards that the measure would have addressed."***

Regulators should have a process in place that considers the following points when deciding if a licensee has done all that is reasonably practicable to meet Article 8a for existing reactors:

- Has the licensee a sufficiently rigorous process to identify shortfalls in preventing and mitigating radioactive releases?
- Is the process shown to be adequate? (e.g. identifies the modern safety standards, encompasses all of the faults and hazards that could lead to a release, all modes of operation, includes Design Extension Conditions (DEC).)
- Has the licensee considered what could be done to remove or reduce the shortfalls? (this should cover all levels in defence in depth that could contribute to prevention or mitigation of radioactive releases, and not be restricted to the specific technology that a new reactor uses to meet the modern safety standard)
- Has the licensee taken due account of national and international practices?

- Of the reasonably practicable options available to reduce a shortfall is the one selected that gives the largest safety benefit?
- Where an option is considered not reasonably practicable has the licensee provided an adequate justification that the measure is disproportionate taking account of the nature and scale of the shortfall?
- Has the licensee considered alternative measures to address the shortfall?
- Has the licensee taken account of the time for implementation in the selection process?
- Do the licensee's processes embrace continuous improvement as well as PSR led improvement?

The above points are not intended to be exhaustive, and it is important to recognise that a regulatory decision on a licensee's proposal that a safety improvement measure is reasonably practicable or not will be dependent on the individual circumstances.

7. References

1 – WENRA statement on safety objectives for new nuclear power plants 2010

http://www.wenra.org/media/filer_public/2012/11/05/wenra_statementonsafetyobjectivesfornewnuclearpowerplants_nov2010.pdf

2 - WENRA Report – Safety of new NPP designs 2013 - http://www.wenra.org/media/filer_public/2013/04/30/rhwg_safety_of_new_npp_designs.pdf

3 – IAEA Vienna declaration on nuclear safety -

https://www.iaea.org/sites/default/files/infcirc872.pdf

4 – IAEA Safety Fundamentals SF1 – http://www-pub.iaea.org/books/IAEABooks/7592/Fundamental-Safety-Principles

5 – WENRA position paper on PSR - http://www.wenra.org/media/filer_public/2013/04/05/rhwg_position_psr_2013-03_final_2.pdf

6 – WENRA RHWG – Pilot study on Long term operation - http://www.wenra.org/media/filer_public/2012/11/05/ltoofnpps_1.pdf.