

HERCA Working Group on Natural Radiation Sources

Second HERCA Workshop on National Radon Action Plans

21-23 June 2022, Lisbon, Portugal



Title:

**REPORT FROM THE SECOND HERCA WORKSHOP ON
NATIONAL RADON ACTION PLANS**

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Working Party on Radon**

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Executive summary

The second HERCA workshop on National Radon Action Plans was organised by the HERCA WG NAT, 21-23 June 2022, Lisbon, at the Portuguese Environment Agency (APA), with support of the Norwegian Radiation and Nuclear Safety Authority (DSA).

Seventy-four participants (41 in person and 33 online) from 22 HERCA member states and international organisations participated in this hybrid-form event.

The main aim of the workshop was to explore the progress made in each country with respect to the main elements of NRAPs, including indicators for assessing the effectiveness of NRAPs, activities for radon control at workplaces and in new buildings as well as challenges and successes related to radon risk awareness and communication.

The promotion of the continuous improvement by sharing successes and weaknesses identified in the HERCA countries was seen as highly important. Some of the questions, such as 'What reference levels have been adopted in different countries and on which basis?', 'What are the best metrics to monitor the impact and effectiveness of the NRAP?', 'How to achieve an optimised radon exposure at workplaces?', 'What roles different stakeholders should play?' were addressed in presentations, discussions and breakout sessions.

Radon is a public health risk, and with respect to the main objectives of the workshop, the status on international and national activities for radon exposure reduction was presented. Five main sessions, each dedicated to a specific radon issue, and roundtable discussions were held in three workshop days.

It was a unique opportunity to share national and international views and to exchange challenges, constraints, and achievements concerning different aspects of the complex radon issue.

Comparing to the outcome from the first NRAP workshop, held in 2014, a significant improvement in many aspects of radon exposure control/reduction in various countries was observed. It was highlighted that the cooperation between different sectors at international, national, regional and local levels is an imperative for success in implementing the national strategies for radon.

Main elements identified in the NRAP of different HERCA countries

- National radon maps are available in most countries – valuable tools, but caution is needed in their interpretation.
- Control of existing exposure in public buildings and dwellings is ongoing, but there is a room for further improvement, for example considering public awareness and proactive attitude, measurements campaigns, information availability, guidelines, voluntarily and mandatory actions, financial incentives and positive impact on remediation.
- Radon measurement protocols, especially for workplaces, should be further improved.
- Preventive measures for radon in new buildings proved to be cost efficient in radon reduction.
- Workplaces – regulatory process with graded approach and use of optimization principle, obligation to measure (certain workplaces and in specific areas), remediation and optimization where needed, control measures and inspections are measures that are highly relevant to have an optimized regulatory approach for radon control at workplaces.
- Communication and stakeholder engagement related to the NRAP – sharing responsibility between stakeholders, communication strategies to be defined at national and international levels, raising awareness of importance for all countries; focus has to be on behavioural change, having communication plans with well-defined target groups.
- Indicators for NRAP - List of indicators is useful, but selection and applications depend on national circumstances; the need for description of which input data are required was identified. HERCA WG NAT will not endorse a harmonized list of indicators that must be used as these may be quite different depending on countries' prevailing circumstances, available resources, etc. It is concluded that, at the moment, no need for a harmonized European list is foreseen. Instead, the exchange about indicators will be continued in coming meetings.

1. Introduction

HERCA is an European association of radiation protection authorities, currently comprising 52 authorities from 32 countries, out of which 27 are EU Member States, hence bound to EU legislation. The remaining 5 countries have national radiation protection laws consistent with the 2013/59 European Basic Safety Standards Directive (EU BSSD) or are committed to adapt their national legislation in order to comply with the EU BSSD requirements.

One of the most challenging aspects of the latest EU BSSD is the regulation of exposure to natural radiation sources, including radon. Following a series of workshops aimed at achieving a common understanding on the Directive requirements on that matter (2014-2016), HERCA created in 2018 a working group on Natural Radiation Sources (WG NAT), committed to pursuing work related to the EU BSSD provisions pertaining to natural sources of radiation, with two subgroups on radon and NORM.

This document is a report from the 2nd HERCA workshop on National Radon Action Plans that was organized from 21-23 June 2022 in Lisbon, Portugal, as one of the main WG NAT activities defined in its action list. The report has been developed by the WG NAT working party on radon, with contributions from participants in the workshop.

1.1. Background

An international workshop about national radon action plan (NRAP) was organized by the HERCA working group on natural radiation sources (WG NAT), with support of the Portuguese Environment agency (APA) and the Norwegian Radiation and Nuclear Safety Authority (DSA). This workshop is as a follow up workshop of the workshop organized on NRAP in 2014 (Paris, France) shortly after the new EU BSSD requirements on radon were introduced and when countries were in the transposition period. In the meantime, the majority of the European countries developed their own NRAPs, and moved from transposition to the implementation of planned activities.

During the information and experience exchange on radon reducing activities within HERCA WG NAT, it became clear that an event should be organized to discuss the current NRAPs status, the implementation of measures, challenges, good practices and lessons learned. Therefore, as a result of the successful collaboration of HERCA member countries on radon issues and a joint vision on the necessity to share views and experiences on radon control activities in European countries, the 2nd HERCA workshop on NRAPs was held during 21-23 June in Lisbon, Portugal. Besides the main organisers, the main contribution was provided by a wide range of organisations (HERCA Members

and other national authorities involved in NRAPs activities) via presentations and discussions, as described in the report.

The report is presented as working material for general information; however, the content should not be taken to represent the official position of the organisations involved.

1.2. Aim and scope of workshop

As mentioned above, the first HERCA Workshop on NRAPs was organized in 2014 to gather and evaluate best international practices for radon reduction in order to support HERCA members in developing their national action plans. Six years later, in 2020, a follow-up Workshop, which aimed at (a) exploring the progress made nationally, and (b) promoting continuous improvement by sharing successes and weaknesses, was planned by the HERCA WG NAT. However, due to global pandemic Covid-19 conditions, this workshop organisation was postponed twice, and finally the workshop was held in 2022.

The main aim of the workshop was to explore the progress made in each country with respect to the main elements of NRAPs, including indicators for assessing the effectiveness of NRAPs, activities for radon control at workplaces and in new buildings, as well as challenges and successes related to radon risk awareness and communication. The promotion of the continuous improvement by sharing successes and weaknesses identified in the HERCA countries was seen as highly important. Some of the questions, such as ‘What reference levels have been adopted in different countries and on which basis?’, ‘What are the best metrics to monitor the impact and effectiveness of the NRAP?’, ‘How to achieve an optimised radon exposure at workplaces?’, ‘What roles different stakeholders should play?’ were addressed in presentations, discussions and breakout sessions.

In order to efficiently discuss all relevant issues, the workshop programme was as follows:

- Welcome address and workshop Introduction
- Session 1 – International organisations and National Radon Action Plan – update on status and activities
- Session 2 – National Radon Action Plan/Indicators
- Session 3 – National Radon Action Plan/ General elements
- Session 4 – Radon at workplaces
- Session 5 – Communication and stakeholder engagement

- Round table discussions on National Radon Action Plan – Indicators and main elements of the plans
- Future radon topics of interest and workshop concluding remarks

1.3. Report structure

This document contains nine sections and two Annexes. Section 1 provides an introduction to the document, including the motivation for this work as well as the workshop aim and scope. Section 2 describes the overview and update of the recent activities of the international organisations (EC, IAEA, WHO) related to national radon action plans (NRAPs) and existing exposure situations. In the sections 3 to 7, abstracts of the oral presentations and oral posters presented at the workshop are provided together with the main questions raised in the workshop. Section 8 gives an overview of the radon topics of interest in the HERCA countries – results of a small survey-exercise done in the workshop preparation phase, but also based on the workshop discussions, while the workshop concluding remarks are given in the final section 9.

Annex I provides the HERCA 2nd NRAP workshop programme, while the list of participants and participants photo are given in the Annex II.

2. Sharing international experience on NRAP

The workshop was opened by the welcoming address kindly given by Ana Teresa Perez (APA, Portugal), followed by the presentation of the workshop background by the HERCA WG NAT Chair, Jelena Mrdakovic Popic (DSA, Norway).

The first workshop session was dedicated to the international organisations and their activities on radon and national action plans. Representatives of the European Commission (Stefan Mundigl, EC), International Atomic Energy Agency (Olvido Guzmán López-Ocón and Haridasan Pappinisseri-Puthanveedu, IAEA) and World Health Organisation (Emilie van Deventer, WHO) and HERCA WG NAT Co-Chair (Wolfgang Ringer, AGES, Austria) presented views and main points in approaches as well as recent activities for radon exposure reduction.

European Commission activities on radon and on national radon action plans

Stefan Mundigl

Team leader Radiation Protection, European Commission, Directorate-General for Energy, Radiation Protection and Nuclear Safety Unit

Europe has a more than 60-year long tradition in protecting individuals from ionising radiation.

Already in the early days of the development and use of radiation generators and radioactive substances in research, medicine, industry and energy production, Europe focussed on the protection of members of the public, workers, and patients from any adverse effects of exposure to ionising radiations. Europe has developed and implemented the most advanced set of legislation aiming at the highest level of protection of individuals exposed to any source of radioactivity or ionising radiation. The main piece of legislation in this respect is the Directive establishing basic safety standards for the protection of individuals against the dangers arising from exposure to ionising radiation – the so-called Basic Safety Standards (BSS) Directive.

Radon, a natural occurring radioactive gas, emanates from rocks and soils and tends to concentrate in enclosed spaces. Radon is the main contributor to the radiation exposure from natural radiation sources, and even more important, is an important cause of lung cancer, after smoking. Being aware of the issue of radon exposure and the associated health risks, Europe decided to introduce in the latest BSS Directive, published in 2013,

for the first-time legal binding requirements to ensure an appropriate protection of individuals from the dangers arising from exposure to radon across Europe.

What are the main requirements on radon in the BSS Directive? Most importantly, European Union Member States are required to establish national radon action plans addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces from any source of radon ingress. Further to this, Member States need to establish national reference levels for indoor radon concentrations both for dwellings and for workplaces, which shall not be higher than 300 Bq/m³. The BSS Directive contains further requirements on the identification of radon priority areas, strategies for radon measurements, prevention of radon ingress into new buildings (building codes), support the mitigation and renovation of existing buildings, and on raising public awareness and providing information (locally, regionally, nationally).

In addition, by setting a reference level for radon in water intended for human consumption, Europe ensures a high-level of drinking water quality regarding radon.

The European Commission is currently busy monitoring the transposition of the BSS radon requirements into national legislations of EU Member States, as well as the practical implementation of actions with regard to radon. To this end, the European Commission has initiated a study assessing and supporting the practical implementation of National Radon Action Plans – the project EU-RAP.

The European Commission is committed to maintain this high level of protection while closely following scientific developments in radiation protection research, which may have an impact on future radiation protection policy.

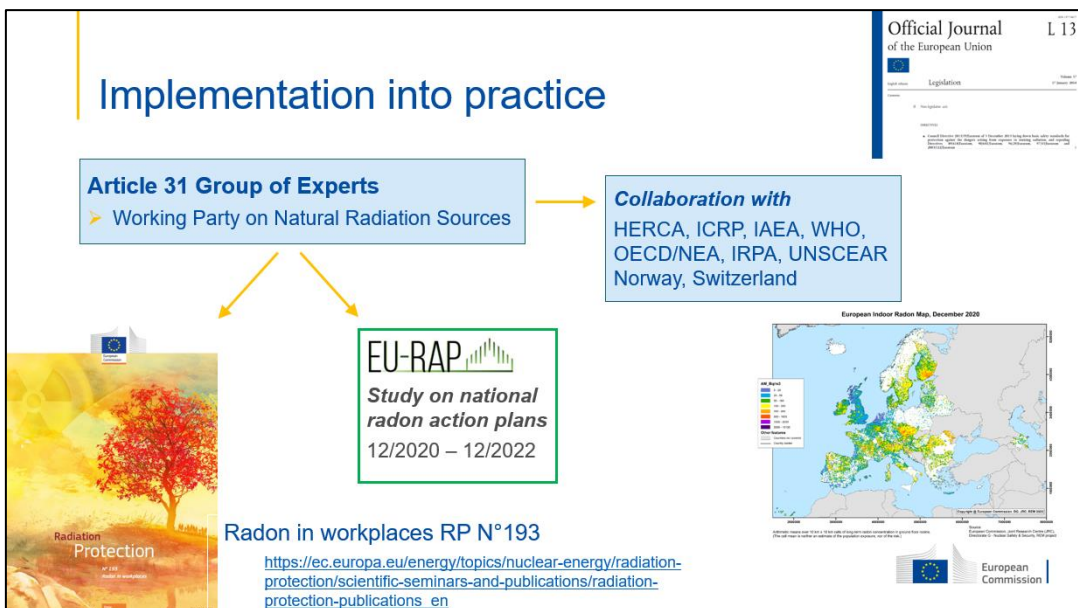


Figure 1. Implementation of EU BSSD radon requirements into practice, overview of certain EC activities.

IAEA Support to Member States in Managing Existing Exposure Situations: Focus on Radon Action Plans (IAEA)

*Olvido Guzmán López-Ocón, Head IAEA NSW/RSM Radiation Protection Unit
Haridasan Pappanisseri Puthanveedu, IAEA NSW Radiation Protection Specialist*

The International Atomic Energy Agency (IAEA) is the world's foremost forum for scientific and technical cooperation in the peaceful use of nuclear technology. Established by the United Nations as an independent organization in 1957, the IAEA serves 175 Member States (as of 2 March 2022).

Among the functions that the Statute attributes to the IAEA its article III, point 6 that states the Agency is authorised “*To establish or adopt, ..., standards of safety for protection of health and minimization of danger to life and property (including such standards for labour conditions), and to provide for the application of these standards ...*”. The [IAEA safety standards](#) reflect an international consensus on what constitutes a high level of safety to protect people and the environment from the harmful effects of ionizing radiation.

Among such harmful effects, for most people, radon is the largest source of radiation exposure throughout their lifetime. Radon is a radioactive gas that has no colour, smell or taste. It is produced in the ground from uranium and diffuses into the atmosphere. High concentrations of radon may build up in enclosed spaces such as buildings and long-term exposure can increase the risk of lung cancer. Radon is the second most important cause of lung cancer after smoking and the leading cause of cancer among non-smokers.

To comply with IAEA Statute to protect against the risk from radon, the [2014 edition of the International Basic Safety Standards](#) requires specific requirements including that national authorities provide general information on radon, including information on health risks and the synergy with smoking. Where there is a need to do so, a national radon action plan should be developed and implemented to reduce the public health risk from radon.

The IAEA has published a safety guide on [Protection of the Public against Exposure Indoors due to Radon and Other Natural Sources of Radiation](#) to assist national authorities in reducing exposure to radon. This safety guide also includes guidance on how to prepare a radon action plan. The Agency has also published technical recommendations of radon [preventive and corrective methods](#) to protect against radon indoors and gamma radiation from construction materials, on [Regulatory control](#)


of [exposure due to radionuclides in building materials and construction materials](#) as well as from [exposure in the uranium mining and processing industry](#).


The IAEA also conducts [webinars](#) specifically on radon, seeking to spread awareness of the associated risks and mitigation methods. Those are targeted at national governments, health care or building professionals and anyone else interested in the topic. Furthermore, the IAEA provides [guidance](#) on designing and conducting indoor radon surveys, as well as on [measurement and calculation](#) of radon releases from mining and milling. The IAEA develops specific recommendation to protect against radon in workplaces. The IAEA develops [training modules](#) that teach the basics of how to initiate national radon programmes.

To further support Member States, in particular European ones, the IAEA carries out [technical cooperation projects](#) on establishing enhanced approaches to control public exposure to radon.

The Agency also discussed with other specialized organizations and agencies and issues documents as the Information overview prepared by the [Inter-Agency Committee on Radiation Safety](#) (IACRS) on managing exposure due to radon at home and at work.

NEW Overarching guidance on Existing Exposure situations





It has been recognised by Member States that **while there are several guidance documents on EES** either already available or in the publication pipeline, **MSs have clearly identified the need for such overarching guidance** .

Objective

- To provide guidance to regulatory bodies and other relevant authorities on implementing the generic requirements of GSR Part 3 in relation to radiation protection and safety of the public, workers and the environment in existing exposure situations.
- To **support consistency in the scope and management of the varied range of existing exposure situations across Member States** and fill the gaps in existing guidance

Figure 2. Development of a new general guidance on Radiation Protection and Safety in Existing Exposure Situations (including radon).

National Radon Action Plans: A global public health perspective

Emilie van Deventer, WHO

Radon mapping of a different kind: Mapping activities and collaborations on radon of international organizations and associations

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In many countries, strategies and action plans to control the exposure from radon are in place. However, not only at the national level, but also at the international level many activities are carried out to support countries in designing and implementing their radon policies. Guidance and technical documents are issued, training is provided, research projects are sponsored, and interaction with various stakeholders is encouraged.

In October 2021, the European Radon Association (ERA) invited international organizations and associations to inform about their specific activities with respect to controlling radon exposure and to explore existing collaborations. The workshop also aimed to identify the need for a better collaboration. Presentations were given by representatives from WHO, IAEA, UNSCEAR, EC, HERCA, ISIAQ, ENBRI, RICOMET, EURADOS, EURAMET EMN-RP, ENA, IRMA, and CARST.

This contribution will summarize presentations and panel discussion and present the main conclusions.

The workshop showed that a high number of various activities exist at the international level but that there is a strong need for more collaboration with the medical sector, the indoor air quality community, and the building sector to address all stakeholders involved in radon protection. The focus should be rather on exchanging experience, share capacities and competences than on the harmonization of procedures.

3. Assessing the impact and effectiveness of NRAP in HERCA Member States

Appropriate indicators are needed to evaluate the effectiveness of the measures to be implemented in the NRAP. This is true in all countries. The main purpose of indicators is to ensure that implementation of the NRAP is resulting in progress towards the overall goal of the NRAP, i.e., to reduce the exposure of the population to radon and related health impact. Moreover, some indicators are also useful to evaluate the progress towards some specific goals that contribute to the overall goal. Indicators can also be used to guide the development of the NRAP and are also valuable to inform the evolution of the NRAP over time. Such indicators could include, for example, the rate of radon testing among the public as well as the rate of radon mitigation among those having high radon concentrations. Furthermore, indicators of baseline data could be useful, such as, for example, the national average indoor radon concentration, compiled or, where necessary, gathered at the start of the NRAP and repeated at appropriate intervals through its lifetime. Additional indicators may need to be developed to assess the evolution of key factors influencing radon risk such as: location, age of construction, building type, etc.

It is worth noting that considerable differences exist between countries in the approaches used to address the radon risk. This is understandable given the diverse climates, geologies and building practices that exist between countries. In addition, while some countries have well developed NRAPs that, in some cases, were published before the adoption of the EU-BSS directive in 2013, other countries have only recently published their NRAPs and are at an early stage in defining the radon problem. Therefore, the NRAPs of Member States can have different quantitative objectives or targets (e.g., to reduce radon levels in different percentages of all the estimated dwellings exceeding the Reference Levels in the country), also considering the graded approach recommended for all radiation protection issues, including radon protection. Optimum indicators should be useful for any different target.

Indicators are not intended to compare the NRAPs of different Member States, but provide them with useful tools to evaluate the effectiveness of the actions included in the NRAP and to monitor the progress towards the targets.

Indicators could also be useful to implement the principle of optimization and the graded approach in NRAPs.

The aim of this session was to share experiences regarding the assessment of the impact and effectiveness of NRAP. The first presentation summarizes the results of the HERCA survey on indicators which was conducted prior to the Workshop as a part of workshop preparation activities. Whereas the second presentation gives an overview of how countries are assessing the effectiveness (as a result of the EU-RAP project), the following three presentations deal with the challenges and experiences with indicators in Ireland, Finland, and Norway.

Results on HERCA WG NAT questionnaires on Rn indicators

Francesco Bochicchio

Istituto Superiore di Sanità, Italy

A group of experts from HERCA WG NAT prepared two questionnaires on radon indicators – one focused on indicators for radon dwellings and the other for radon in workplaces – that have been distributed to the HERCA WG NAT members to collect information on the use of indicators in their country. The two questionnaires have been prepared taking into account the previous HERCA WG NAT activities on indicators, including the paper published in 2022 on the International Journal of Environmental Research and Public Health.

Each questionnaire contains questions on 14 indicators grouped into 6 sections (plus 1 section on responders): 1) Data on responder; 2) Measurements of radon concentration in dwellings/workplaces (4 questions); 3) Estimated and identified dwellings/workplaces exceeding the RL (3 q.); 4) Remedial actions in existing buildings and preventive measures in new ones (4 q.); 5) Training courses on remedial/preventive actions in dwellings/workplaces and available experts/services (3 q.); 6) Public information and radon awareness (2 q.); 7) Overall impact (4 q.).

For each question, i.e. for each indicator, one of the followings 4 options could be selected as answer: A) It has been already considered and it is actually in use, or it is planned to be used, within the NRAP of the country; B) It is still under consideration or it could be considered; C) It has been already considered but it has been decided not to use it (in this case the reasons for such decision were asked); D) Don't know if the indicator has been (or it will be) considered. Moreover, adopted indicators other than the proposed 14 ones could be reported.

The detailed list of the 14 indicators is reported in section 7 of this Report.

The received answers were 19 from 18 countries (Austria, Belgium, Croatia, Czechia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland, United Kingdom) for dwellings, and 18 for workplaces.

For each indicator and for each option (A, B, C, D) the number of answers has been presented. In most of the cases, the number of answers for options A and B was quite high (14 or more, out of 19 and 18 for dwellings and workplaces). Moreover, further 15 and 11 other indicators have been reported for dwellings and workplaces, respectively.

In conclusion, the indicators included in the questionnaires are usually already in use, or planned to be used, or under consideration. Such indicators have been excluded only in few cases. Further indicators are also considered by some countries. Some indicators could benefit from a guideline on how to evaluate them.

Reference

Bohicchio, F.; Fenton, D.; Fonseca, H.; García-Talavera, M.; Jaunet, P.; Long, S.; Olsen, B.; Mrdakovic Popic, J.; Ringer, W. National Radon Action Plans in Europe and Need of Effectiveness Indicators: An Overview of HERCA Activities. Int. J. Environ. Res. Public Health 2022, 19, 4114. <https://doi.org/10.3390/ijerph19074114>

Assessing the effectiveness of Radon Action Plans: searching for a systematic and standardised method

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After transposing and implementing the 2013 Basic Safety Standards on the national level, one of the greatest challenges is how to evaluate its effectiveness. This question is investigated as part of the EU-RAP project, funded by DG Energy.

The EU-RAP consortium, with the collaboration of the EU-RAP Reference Group, have developed a methodology to assess the strategies and the practical implementation of the actions defined in radon action plans (RAP). The first part of the assessment – the extent to which the approved radon action plans define or cover the elements of the Annex XVIII of BSS and education and training – is rather straightforward as the consortium carefully analyses the content of the RAP and cross-checks the information, through a group interview, with the relevant authorities. After the content analysis of the RAP from 27 EU Member States and the UK, group interviews were conducted with all authorities responsible for implementation in all Member States. In addition, four regional workshops were organised to understand countries' specificities regarding

radon management and discuss the challenges in protection from radon. Throughout the whole study, special focus was given to search for a systematic and standardised method for assessing the effectiveness of RAPs. These research activities were conducted from March 2021 until May 2022.

This contribution will present an overview of how countries are assessing the effectiveness and the experience of EU-RAP assessment. Results show that there is a remaining challenge regarding how to evaluate the effectiveness of the RAP in achieving its objectives. A few countries have already a set of criteria or indicators which facilitate the review of their national radon action plans. However, there is not yet a common set of criteria or indicators to measure the effectiveness of the different elements of the RAP.

For each of the 14 items defined in Annex XVIII of the BSS and education and training, the EU-RAP project has defined a set of guiding questions to assess the effectiveness of these items with regards to the implementation phase of the RAP. The EU-RAP proposes to merge some of these elements, and defines a common, independent and standardised evaluation system. This contribution is of benefit not only to all the owners of RAP but also to HERCA, since HERCA is working on the development of indicators to evaluate the effectiveness of RAPs.

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Indicators and Targets in Ireland's NRAP

David Fenton

EPA, Ireland

Ireland's NRAP was launched in 2014 along with a supporting strategy setting out the research needed to support implementation of the NRAP. The metrics used to monitor the effectiveness of this work will be presented. The use of both "leading indicators", which give a real-time measure of progress towards reducing exposure, and "lagging indicators", which provide information that may not be sufficiently timely to helpfully direct ongoing actions, will be discussed.

The challenges experienced, and lessons learned while implementing actions under each of the five themes of the NRAP will be discussed. These themes are: prevention in new buildings, the use of property transactions to drive action on radon, communications

and advocacy, promoting confidence in radon services and radon in workplaces and public buildings. It is clear, that the implementation of the NRAP is a long-term, slow process and to ensure continuity, the importance of partnering with a wide range of stakeholders will be discussed.

Performance Indicators in the Radon Action Plan of Finland

Päivi Kurttio, Marjo Perälä, Katja Kojo, Tuukka Turtiainen, Olli Holmgren

Radiation and Nuclear Safety Authority, Finland (STUK)

As part of the national implementation of the Basic Safety Standard Directive (2013/59/Euratom), a Radon Action Plan (RAP) was included in the Finnish Radiation Act and the Government Decree on Ionizing Radiation. Radon management is included in the Finnish radiation regulation, and e.g. reference levels are set in the Decree of the Ministry of Social Affairs and Health. The RAP was introduced and discussed with stakeholders and it was published in 2020. RAP is due to be updated every five years. The steering committee of RAP included representatives of Ministry of Social Affairs and Health (chair and the responsible body), Ministry of Environment, National Supervisory Authority for Welfare and Health, regional health protection authority, regional occupational health authority, the Association of Finnish Local and Regional Authorities, and STUK (coordinator).

The main goals of the RAP include:

- reduction of radon related lung cancers by reducing radon exposure and smoking
- reduction of radon exposure by enforcing compliance of the regulations and by encouraging responsible bodies to act in order to ensure radon-safe buildings
- further developing national radon database which can be used for example in graded approach of regulatory control
- increasing radon risk awareness

Some potential performance indicators to monitor the impact and effectiveness of the RAP will be presented and discussed:

1. Time trend of radon concentrations in new buildings.
2. Time trend of radon concentrations in dwellings.
3. Time trend of radon concentrations in workplaces.
4. Time trend of number of entries in the national radon database.
5. Number of cases in radon regulatory control.

[National action plan to prevent radon risks - stuk-en - STUK](#)

<https://julkaisut.valtioneuvosto.fi/handle/10024/163672>

Assessing the impact and effectiveness of the Norwegian Radon Strategy

Bård Olsen

Norwegian Radiation and Nuclear Safety Authority (DSA)

Indoor radon is estimated to cause approximately 370 cases of lung cancer each year in Norway. High radon levels in Norwegian homes and other buildings are due to Norway's specific geological conditions and cool climate.

The "Strategy for the reduction of radon in Norway", our national radon action plan (NRAP), was adopted by the Norwegian government in 2009. The strategy was harmonized with the recommendations of the WHO Handbook on Indoor Radon and consistent with the EU BSS requirements for a NRAP. The Norwegian Radiation and Nuclear Safety Authority (DSA) was designated the task of creating and leading a coordination group which would work with implementing the strategy. This group was established with representatives from relevant public authorities, like the health authorities, the labour authority, and authorities within building and land planning. During the strategy period, the group has served as a forum for mutual information and harmonisation of radon-related activities, including radon regulation. Initially, the radon strategy period was five years, but the period was extended until 2020.

The two strategic goals in the national radon strategy were: "Work towards reducing radon levels in all buildings and premises to below the stated limits, and, contribute to reducing radon exposure in Norway to as low as reasonably achievable." In 2020, DSA worked together with the coordination group to evaluate the NRAP work. It has not been straightforward to monitor the impact and effectiveness of the radon strategy with regard to the stated goals. Therefore, to measure the strategy implementation success, or lack of success, a list of indicators was created. The purpose of these indicators was not to measure what is achieved, but to measure the effect the achievements have had in society. Specific indicators were provided for the radon strategy's six sub targets, which dealt with land planning, new build, existing dwellings, communities exposed to especially serious radon problems, public buildings including schools and kindergartens and radon in the workplace.

The evaluation formed the basis for a new and updated radon strategy. In 2021, a proposal for a second national radon strategy for Norway was developed by DSA and the coordination group. In addition to the evaluation of the previous radon strategy and discussions in the coordination group, identified stakeholders were invited to contribute. In December 2021 DSA finalized the proposal for a new radon strategy, which is currently being considered by the Ministry of Health and Care Services and will hopefully be published in 2022.

4. Main elements in NRAP of HERCA member states

The EU BSSD requires Member States to put in place NRAPs. Annex XVIII of the Directive sets out the list of 14 items that must be taken into account when developing them. This session on Radon Action Plans gave the opportunity for countries to highlight how they have implemented this requirement. The session included 8 oral presentations from Portugal, Switzerland, France, UK, Czech Republic, Romania, Slovenia and Germany. The session included 5 short poster presentations from Italy, Hungary, Spain, Slovak Republic and Serbia.

The session showed how different countries approached implementing Annex XVIII. This was normally done by grouping the 14 items under defined “Pillars” or “themes” that, depending on how advanced the radon programme is within the country, better described where the items best fitted within the national framework. Example of the Pillars/themes that countries use include:

- Characterise, Reduce, Communicate
- Building Stock, Health Risk, Radon Expertise, Employee Protection
- Information and awareness raising, continuing to improve knowledge, improve the management of the radon risk in new and existing buildings
- Informed state administration, involved public, educated professionals; Effective prevention in new construction and reconstruction of buildings; Effective control of existing exposure
- Promoting confidence in radon services, radon prevention in new buildings, radon in workplaces/public buildings, communications and advocacy

The session showed also that HERCA WG NAT was helpful in exchanging experiences and sharing common challenges. An example of such a challenge was how to train radon remediation expertise and to encourage radon remediation among the public by having confidence radon remediation contractors.

The development of the Portuguese NRAP

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The effects of radon exposure on human health are well known and strategies to deal with the risks from long-term exposure need to be established. In Portugal, despite the fact that the radon has been studied since the 1980s, there is no instrument that addresses this issue in an integrated manner, enabling the risks of long-term exposure to be dealt with in an effective and sustained manner.

In this context, Decree-Law No. 108/2018, of 3 December, which establishes the legal regime of radiological protection, created the obligation of a National Radon Action Plan (NRAP), entrusting its development to the Portuguese Environment Agency (APA), as the competent and designated authority for this purpose. The NRAP should contain a set of requirements and actions aimed at reducing long-term risks from exposure to radon in dwellings, workplaces and buildings open to the public.

The vision of the Portuguese NRAP is to ensure protection against the risks of radon exposure in a multisectoral way and to reduce its health effects in a sustainable way, the NRAP has 6 operational objectives based on 3 pillars of action:

Pillar 1 -Characterise - through knowledge and diagnosis of exposure situations and the structure of protection of workers and the general public;

Pillar 2 - Reduce – by identifying actions leading to more efficient and sustainable radon exposure mitigation systems combined with the provision of quality services;

Pillar 3 - Communicate - with the design of guidelines for the definition of adequate communication strategies and the creation of mechanisms for a wide dissemination of information to the general public and dedicated to different target audiences.

In order to achieve the operational objectives, Definition of Methodological Guidelines (1), Promotion of R&D (2), Reduction and Management of Exposure (3), Promotion of Quality of Service Providers (4), Dissemination and Information Management (5), Communication and Interaction with the Public (6), a set of actions linked to quality, proficiency and governance were defined, focusing on several areas of intervention considered fundamental, namely:

- Diagnosis and delimitation radon risk areas;
- Reduction of radon levels in buildings;

- Management of radon in workplaces and protection of employees;
- Assessment of whether it is appropriate and/or necessary to change the reference level;
- Definition of a communication strategy towards the public and stakeholders.

To support the evaluation of the NRAP in Portugal, a set of metrics comprising two types of indicators were considered. Efficiency Indicators, which refer to the achievement of the measures within the stipulated timeframe and the Effectiveness Indicators, which are complementary indicators that provide evidence that the long-term objectives will be achieved (e.g. the number of tests carried out in homes and workplaces, the remediation rate in existing buildings, number of service providers recognised, number of hits on the website and on the potential map). While Efficiency Indicators are only associated with strict compliance with the defined timeline, Effectiveness Indicators are more complex and are closely linked to the specificity of the actions defined in the plan.

The NRAP is a 5-year plan, the indicators will be key to the review process and to support the development of the subsequent NRAP, identifying which strategies should continue and proposing new approaches that may be needed for the new 5-year cycle.

Swiss National Radon Action Plan 2021-2030

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Due to geological reasons, Switzerland is strongly affected by the radon problem. The first measurement campaigns and investigations of possible methods to reduce the radon level in a building were conducted in the 80th and 90th. These studies showed that in particular the alpine region and the Jurassic arc are concerned and that many buildings in these regions have high radon concentrations.

In order to tackle the radon problem in Switzerland the federal council approved the radon action plan 2012-2020 with various measures. One of the goals of this plan was the revision of the radon legislation in Switzerland. Based on this new legal framework, the assessment of the accomplishments of the action plan, and international recommendations a new radon action plan for the next ten years (2021-2030) was developed. This new action plan defines four lines of action and corresponding goals:

Building stock: Radon protection in building stock must be sustainably improved, in particular by creating synergies with energy-efficiency measures in buildings.

Health risk: Public awareness and understanding of the health risk need to be improved, which will result in the issue of radon gaining importance.

Radon expertise: In order to meet the increased demand for planning and implementation of radon protection measures in new buildings and remediation projects, radon expertise among builders, planners, architects and radon experts must be improved and expanded.

Employee protection: Radon protection must be guaranteed in the workplace, for employee protection and to prevent occupational diseases.

The four lines of action in the Action Plan will each be accompanied by innovative digital solutions, information campaigns, and research projects. In order to implement the lines of action we will work together with several organizations, such as the cantons, the Swiss Federal Office of Energy and partners in the constructions and health sectors. The new radon action plan shall thus pave the way to reach the goal of optimally protecting the Swiss population from radon.

The 4th French national action plan for management of the radon risk

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In the 1980s, France initiated steps to characterize this risk through a national campaign of measurement in the home and manage it through an appropriate body of regulations. Since 2005, these technical and regulatory measures have been accompanied by three consecutive national actions plans for management of the radon risk.

The 4th national action plan for management of the radon risk (PAR4) for the period 2020-2024 is currently being validated in France. The document was drafted jointly by the Nuclear Safety Authority (ASN), the ministries responsible for health, the environment, construction and labour, national experts including, the Institute for radiation protection and nuclear safety (IRSN), regional stakeholders, radon measurement professionals and the associations intervening on this subject.

The 4th plan incorporates the regulatory provisions resulting from the transposition of Directive 2013/59/Euratom of 5th December 2013, with the reinforcement of the regulations in places with open access to the public, workplaces and dwellings.

The plan focuses on three priorities and 13 actions:

- Priority 1: set up an overall strategy for information and awareness-raising of all stakeholders (local authorities, employers, building professionals, health professionals ...) and the general public, at a national level national and at a local level. In order to extend the scope of awareness-raising actions on radon, actions must be implemented in synergy with indoor air quality and energy efficiency measures.
- Priority 2: continue to improve knowledge. This priority includes:
 - an additional work to clarify the influence of certain aggravating geological factors (underground cavities) which were not taken into account in the new mapping of radon areas published in June 2018 dividing the territory into 3 levels of radon potential,
 - the implementation of a database accessible to the population gathering all the results of radon measurements,
 - organizing the collection of measurement data to update the exposure of the population.
- Priority 3: take better account of the management of the radon risk in buildings with the collection of data on the effectiveness of prevention methods in new constructions and remediation in existing constructions and the dissemination of good practices to construction professionals.

Indicators have been put in place to monitor the effectiveness of the plan.

The United Kingdom Experience of Creating its First National Radon Action Plan

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Radon is the single largest source of radiation exposure to the UK population in both homes and workplaces. It is probably the second most important cause of lung cancer after tobacco smoking, with which it has a strong synergy. The 2013 European Union Basic Safety Standards Directive on protection against ionising radiation^[1] described in detail the actions that EU Member States should take to protect the population from radon exposure. This included a list of 14 items to be considered as part of a national radon action plan (NRAP) and explicitly referenced in national legislation^[2].

The Radon Group at UKHSA (formerly Public Health England, PHE) led a cross-government project to produce the UK NRAP that provided:

- information on the health risks from public exposure to radon;
- national strategy and arrangements for managing exposure to radon in homes and workplaces;
- arrangements for government and private industry to communicate radon guidance to the public and local authorities; and
- new programmes to be considered.

The NRAP was subject to a public consultation in summer 2018 and the revised version^[3] published in December of that same year. The presentation will describe the development of the NRAP, how it can be used as a reference document for radon in the UK, the ways in which this work has developed over the past few years, and preparations for the second NRAP due in 2023.

References

1 Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation. EC 2013. <https://eur-lex.europa.eu/eli/dir/2013/59/oj>

2 The Ionising Radiation (Basic Safety Standards) (Miscellaneous Provisions) Regulations 2018. SI 2018/482. <https://www.legislation.gov.uk/uksi/2018/482/contents/made>

3 McColl NP, Bradley EJ, Gooding TD, Ashby C, Astbury J, Atkinson J, Harrall R, Howard T, Hunt J, Kernohan D, James K, Jones R, Lavery J, McMahon N, McNicholas C, Moss L, Murphy L, Netherwood T, Rankin P, Stewart M, Taylor J, Tink V, Waldron G, Wasson G. UK National Radon Action Plan. PHE-CRCE043. <https://www.gov.uk/government/publications/uk-national-radon-action-plan>

Radon action plan of the Czech Republic

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Radon action plan of the Czech Republic defines three main long-term objectives aimed at the control of public exposure to radon in buildings, schools, and in workplaces:

1. Informed and communicative state administration, involved public, educated professionals
2. Effective prevention during the construction and reconstruction of buildings
3. Effective control of an existing exposure

Practical examples of putting these ambitious aims into practice will be presented: educating of the administration, public and professionals, preparation of a new Radon national database and implementation of a compact national program of the radon exposure control at schools and preschool facilities.

Implementation of the radon national action plan in Romania - status and perspectives

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The exposure due to radon is the biggest concern for public exposure, therefore the risks associated with radon exposure should be carefully considered by countries. The Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom [1], requires to member states to develop and implement actions in order to minimise the exposure to radon.

The paper describes the individual actions and strategic directions of radon national action plan developed in order to transpose the Council Directive 2013/59/Euratom in regard with radon.

The Radon National Action Plan is structured on seven strategic directions covering: development of regulatory framework, measurements of indoor radon and

development of radon map, identification of indoor workplaces and other workplaces with high exposure radon risk, implementation of prevention action in new buildings, information and awareness of public, minimisation of lung cancer risk due to radon, training and education of professionals who could be affected by exposure to radon[2]. The paper describes as well, the status of the implementation of the actions in the Radon National Action Plan.

References

[1] *2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, Official Journal of the European Union, L 199/48.*

[2] *Governmental Decision 526/2018 approving the Radon National Action Plan.*

National Radon Action Plan in Slovenia

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The average annual effective dose from natural sources received by a single individual in Slovenia is between 2.5 and 2.8 mSv. It is estimated that indoor exposure to radon represents around half of the average individual exposure (1.2–1.5 mSv per year). In 2018 Slovenia brought into force national legislation in accordance with Council Directive 2013/59/Euratom. In line with the directive also national radon action plan addressing long-term risks from radon in dwellings, buildings with public access and workplaces was prepared and adopted the same year. Reference level for annual average indoor radon concentration for dwellings and workplaces was established at 300 Bq/m³.

A radon map was developed based on existing data of radon concentrations in the ground, geological characteristics of the ground underneath the buildings and indoor radon measurements results. Areas with higher radon concentration were delineated and 24 out of 212 municipalities were declared as areas with higher radon concentration, representing 22% of the total area (Figure). In the areas with high radon concentration nearly 200,000 inhabitants or 9,4% of entire population are living, while approximately 60,000 or 6.5% of all workers are employed there.

The existing survey program in schools and kindergartens covers radon concentration measurements in approximately 150 buildings annually. Nearly 500 measurements in dwellings predominantly in basement or ground floor has been financed by the government since 2018. Interested individuals can also borrow devices from the Slovenian Radiation Protection Administration (SRPA) to make their own indicative radon concentration measurements in their dwellings. At the same time, they have the opportunity to talk directly to the expert.

Radon measurements in workplaces are part of the risk assessment process leading to decisions whether radon exposures should be controlled through remediation or other means. By the year 2021 the employer shall ensure radon measurements at workplaces on ground levels and in basements in areas with higher radon concentration and at locations where increased radon concentration can be expected, such as in spas, pools, caves, mines, etc. Measurements have to be repeated whenever the situation affecting the radon concentration significantly changed (for example larger building reconstruction).

Register of radon measurements was developed in 2018. Accredited technical support organizations performing radon measurements report all results to the Register, which will ease to assess radon exposure in the future. Slovenian National Building and Civil Engineering Institute in cooperation with SRPA prepared guidelines how to prevent radon ingress and high radon exposures in new buildings as well as to facilitate post construction remedial actions to reduce radon concentrations. Radon concentration reducing measures were introduced and incorporated into programmes on energy saving and indoor air quality. In public buildings used for the childcare, education, cultural or health care programs, the resources for implementing measures for reducing radon exposure shall be provided by the government.

The European Code Against Cancer recommending reduction of high radon levels, triggered involvement of Institute of Oncology, Slovenian Cancer Registry, National Institute of Public Health and Slovenian Association Against Cancer in a variety of activities leading to increase public awareness of radon related health risk as well as addressing differences in risk for smokers compared to non-smokers. There are nearly 1,500 cases of lung cancer in Slovenia annually, therefore long-term goals to reduce lung cancer risk attributable to radon exposure present challenges for public health. Based on SRPA initiative Institute of Oncology and Slovenian Cancer Registry started a study analysing correlation between lung cancer incidence and radon concentration in Slovenian municipalities. It is foreseen that preliminary results will be available in 2022.

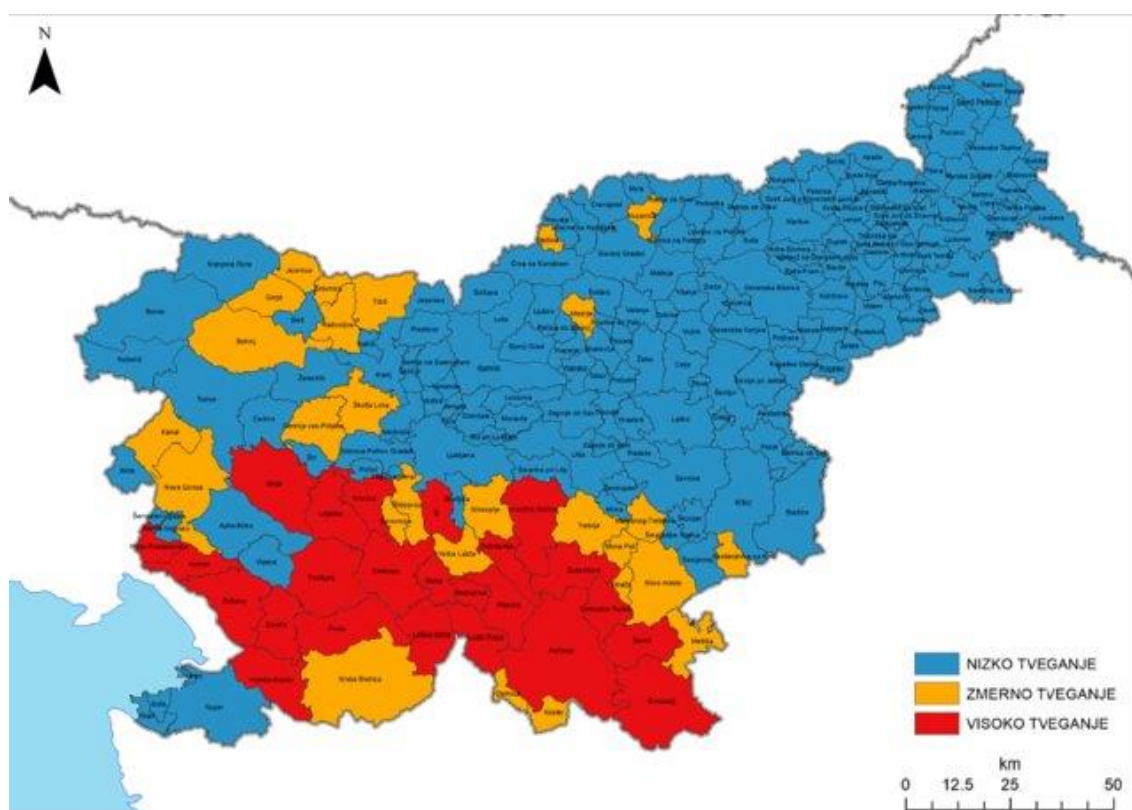


Figure 3: Categorization of Slovenian municipalities based on average radon concentration (red: higher radon concentration area, orange: moderate radon concentration area, blue: low radon concentration area).

To reach different groups of people SRPA uses different channels of communication. Targeted communications include invitations to participate in government-funded radon surveys, informing and encouragement of local decision makers and communities to attend events focused on radon surveys and remediation measures, sending leaflets about radon and its related health risks to schools and participation in local newspapers, publications, radio and television programmes as well as web presence. It is foreseen that Slovenian radon action plan to be reviewed each five years.

Protection from Radon in existing residential buildings in Germany

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The Euratom basic safety standards directive 2013/59/Euratom has been transposed into German legislation in 2018. With this, in Germany, for the first time, regulations for the protection of the general public from the exposure to radon are in place. Existing regulations for the protection from radon at workplaces have been extended substantially. The responsibility for the implementation of the new legislation is divided into responsibilities of the federal government and – for the majority of the regulations – responsibilities of the federal state (*Länder*) governments. Regulations require that a radon action plan is prepared by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (short Federal Environment Ministry). The federal states were contributing to the preparation of the radon action plan.

The radon action plan has been released in April 2019 and defines 23 measures of the Federal Environment Ministry and the federal states for the sustainable reduction of radon exposure in Germany. The areas covered by the radon action plan are public relations work, survey of radon occurrence and identification and designation of radon prone areas, measures to prevent or significantly impede radon ingress into habitable rooms in new and existing buildings, radon in the workplace, research on radon and protective measures, and the evaluation of the implementation of the measures. The implementation of the radon action plan is coordinated by a steering committee that is chaired by the Federal Environment Ministry. The radon action plan will be updated the latest every ten years. At the end of the ten-year period, the Federal Environment Ministry will prepare a report about the effectiveness of the measures and the development of the protection of the public from radon in Germany.

Regulations for mandatory protective measures exist for new buildings with habitable rooms or workplaces and for existing buildings with workplaces. These regulations provide a good protection from the exposure to radon. However, for existing residential buildings there are no mandatory requirements for remediation measures, instead the state appeals to the building owners' sense of responsibility for the protection from radon. A set of measures in the radon action plan aims at supporting building owners in their decision to perform remediation measures. An example for these measures is the development of a harmonised base for radon communication between federal and federal state level. This includes key statements, target groups and possible multipliers for information measures. Furthermore, one of the measures of the radon action plan is the review and, if deemed appropriate, implementation of financial incentives for the

remediation of residential buildings with habitable rooms. A research project has been executed in the research plan of the Federal Environment Ministry to study the potential of financial incentives to increase the number of radon remediations in Germany. The presentation will cover the outcomes and current state of measures of the radon action plan for the protection from radon in existing residential buildings.

An English language version of the radon action plan is available for free download on the webpage of the Federal Environment Ministry: <https://www.bmu.de/PU560-1>

Towards the Italian National Radon Action Plan

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In August 2020 Italy adopted the new legislative decree which transposes the Council Directive 2013/59/EURATOM.

The legislative decree, among the important new elements regarding the protection of workers and the public from exposure to radon, establishes the elements to be considered for the National Radon Action Plan, and entrusts the Ministry of Ecological Transition and the Ministry of Health, with other competent administrations, with the task of drawing up the Plan.

A formally established working group has completed the elaboration of the Plan, which covers all the elements of Annex XVIII of the Directive, including four main topics:

- a strategy for the reduction of long-term risks from radon exposures in dwellings, workplaces and public buildings;
- the criteria for the identification of radon priority areas;
- the technical rules to prevent radon from entering new buildings;
- the definition of indicators for monitoring and verifying the effectiveness of the actions.

The National Radon Action Plan is structured in three strategic axes concerning the tools for: the identification of situations of major exposure, the prevention and reduction of indoor radon concentration, the information, education, training and dissemination. Each axis is divided into areas of action characterised by starting scenarios and

objectives to be achieved, with performance indicators and defined coordination roles and responsibilities. The Plan, to be implemented over ten years according to a detailed timetable, also contains attached guidelines, indications and technical elements aimed at making the most important activities immediately operational.

The Ministry of Ecological Transition and the Ministry of Health have formally initiated the legislative process for the approval of the National Radon Action Plan, which, according to current legislation, must be implemented by a President of the Council of Ministers decree.

National Radon Action Plan in Hungary

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The work on the Hungarian National Radon Action Plan (RAP) was started in 2015 as collaboration between scientific radon laboratories operated by universities and the 'FJC' National Research Institute for Radiobiology and Radiohygiene (NRIRR). The RAP was prepared in 2017, and was approved and published by the Government in 2019. The RAP contains general objectives and requirements for the Hungarian radon program. The program covers the following issues: representative national radon survey, corrective and preventive actions, epidemiological study, communication strategy, governmental subsidy system, ministerial responsibilities. The work on the concept of the implementation of the radon program with special focus on the new national radon survey was started after that. The planned radon survey involves the following types of measurements: indoor radon concentration and gamma radiation measurements, soil gas concentration, gas permeability and radioactivity measurements, testing spring waters for radon. The radon program includes other objectives, as well, such as communication strategy, mapping and assessment of biological hazards attributable to radon exposures. The preparation of the radon program was started in 2021. The main focus was on the development of technical infrastructure, methods and human resources. The implementation of the program will start with the indoor radon survey and geogen radon potential field measurements in 2022.

CSN Activities in the frame of the 1st National Radon Action Plan of Spain

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Under the European Basic Safety Standards Directive, Member States are required to establish national action plans addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces (Article 103). The first National Radon Action Plan in Spain will cover the period 2022–2026 and will be renewed as five-year programmes.

The Plan represents the collaborative effort among five national regulatory authorities, autonomous regions and local entities, aimed at eliminating avoidable radon-induced lung cancers. It will be structured in five key thematic areas, plus an additional coordination module:

- Core knowledge and infrastructure
- Building
- Occupational exposure
- Radon priority areas (instruments supporting the realisation of local action)
- Public communication

The activities undertaken by CSN spread across four of those five thematic areas. They represent a continuation of the developments that CSN commenced decades ago, but will be strengthened by an increased stakeholder engagement and a more fluent institutional collaboration.

This work summarizes those activities as well as the developments made in the past two years, in preparation of the National Radon Action Plan. The strengths and the main challenges in the implementation of the Plan, in the scope of CSN's competences, are also described.

NATIONAL ACTION RADON PLAN OF THE SLOVAK REPUBLIC

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Keywords:

National action radon plan, radon survey, radon prone areas, public awareness

Abstract:

Resulting from the EU Council Directive 59/2013/EURATOM, Public Health Authority of the Slovak Republic (hereinafter “PHA SR”) has prepared the National Action Radon Plan (hereinafter “NARP”) that has been approved by the Government of the Slovak republic. The implementation has started in January 2022.

According to the World Health Organization, national radon programs should focus to identify the geographical areas where most people are exposed to radon. At the same time, they should focus on raising public awareness of the health risks associated with the presence of indoor radon. All of these goals are going to be fulfilled by a realization of NARP.

As a result of the changing lifestyle of the population in recent decades and following energy-saving measures in buildings, it is necessary to examine doses of the population due to radon exposure and, if necessary, to propose preventive measures, as well as corrective actions.

NARP includes three different phases. The first one was the preparatory phase of NARP that was completed in 2021. It included the determination of reference levels for annual average radon volume activity. The pilot radon survey has been conducted during this phase. Slovak Republic has been participating in the IAEA STEAM project and preparation of e-learning materials on radon topics as well. The second phase will be implemented in 2022 – 2026. Radon prone areas will be identified during this phase, public awareness will be increased by information technology such as social media.

Selection and conducting of the preventive and corrective measures to reduce the occurrence of radon in dwellings and workplaces will be the last but not least goal of this phase. The third phase (2027 – 2031) will depend on the results of the previous stages of the NARP implementation.

Draft document radon action plan in the republic of Serbia

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Pursuant to the Law on Radiation and Nuclear Safety and Security (Law) (*Official Gazette of RS*, No. 95/18 and 10/19), Serbian Radiation and Nuclear Safety and Security Directorate (SRBATOM) is responsible to prepare and to propose to the Serbian Government, four strategies in the field of radiation and nuclear safety and security. The strategies are intended to be adopted for the period of seven years. Strategies comprise Action plans for their implementation as their inherent parts. Action plan shall include measures for the achievement of general and particular goals defined by the strategy. One of the issues within the scope of the Existing Exposure Situation Management Strategy is radon.

Generally, radon is not an issue in the territory of Republic of Serbia based on the surveys conducted in the past. However, it must be noted that the reference levels of 300 Bq/m³ have not been set in Serbian regulations yet. Very high radon concentrations are measured in a small percentage of dwellings, workplaces and public facilities. These high concentrations result in doses which should not be disregarded from the radiation protection point of view. SRBATOM informed the stakeholders about the issues. However, further steps related to remediation and mitigation were not taken except additional measurements at one site. All the results so far, as well as the activities that have been carried out, indicated that Systematic Action Plan regarding the radon issue in Serbia needs to be adopted.

According to the justification process related to the recognised radon issues in the Republic of Serbia Existing Exposure Situation Management Strategy defines following goals which will be implemented through the Radon Action Plan (RAP) for upcoming seven-year period:

1. Establishment of reference levels for dwellings and workplaces

To achieve this goal first step should be review and revision of the legislation in the field. Process of adopting legislation should include all recognized stakeholders. In accordance with the Law, SRBATOM is responsible for passing bylaws.

2. Establishment of Action Plan for radon mitigation in Niska Banja

According to the radon risk assessment, the area of Niska Banja might be identified as a radon prone area. The efficiency in tackling radon issue would be achieved through the preparation of the local Action Plan. The task of preparing the Action Plan would be the responsibility of the Radon Working Group (RWG), consisting of the representatives from local self-government, the representatives of the regulatory body, radon experts, geologists, building professionals, medical experts and local public representatives, and other local institutions in the field of environmental protection.

3. Establishment of radon control in workplaces

Radon protection measures in workplaces in Serbia are to be implemented using the graded approach. As priority according to justification principle, first should be deal with workplaces in radon prone area such as Niska Banja (strategic goal 2). After that, workplaces in future recognised radon prone areas or other locations on the ground floor or basement level and workplaces in a fields of work where high radon activity concentrations is expected, such us mines, drinking water treatment and supply facilities, and radon baths when radon concentrations are above reference level.

4. Radon measurement capacity assessment in the Republic of Serbia

Radon measurement capacity in the Republic of Serbia is limited to a few accredited methods for indoor radon measurements. Only one laboratory has the accreditation for radon measurement in drinking water. SRBATOM should ensure that across their territories, high technical standards are assured in all aspects of the radon measurement process. This will ensure that the same standards are applied across all laboratory, and that measurements and services will be consistent and comparable over time. To achieve this SRBATOM should set performance standards that must be demonstrated by services. These may include standards for types of detectors, measurement periods

and corrections, detector placement protocols, QA/QC procedures required, equipment standards and training standards for service providers.

5. Remedial activities to mitigate consequences of radon exposure

Preparation of the national system for reducing radon levels in dwellings and workplaces through the implementation of corrective actions in the existing buildings and preventive measures in new buildings will be one of the main steps to reduce radon risk in the Republic of Serbia. Radiation protection from radon exposure should be incorporated into the education, further education and training courses that are provided for building experts, architects, energy consultants and other relevant occupational groups.

The measures to reduce radon activity concentration in the air in the existing buildings and the measures to prevent or significantly impede radon ingress into dwellings in new buildings will be the main focuses of the remedial activities for radon mitigation. In order to conduct all intended activities, it is necessary to include all recognized stakeholders.

6. Raise awareness of radon risk

There is often a lack of awareness among the public and workers regarding the health risks of radon exposure. In order to make this topic accessible to the wider public, and make the associated legal provisions more understandable, the comprehensive measures on informing all relevant target groups need to be initiated. The objective is to make comprehensive information on the health impact of radon, the manner of measuring radon and possible construction measures to protect from radon available to the public.

In a seven- year period, the measures to achieve this goal will be realised through the following:

- Preparation and implementation of Communication Strategy including risk associated to radon and smokers and risk associated to reconstruction of houses to enhance energy efficiency

The Existing Exposure Situation Management Strategy with the Radon Action Plan should be adopted during 2022.

5. Radon at the workplace

The session on radon protection at the workplace included four oral presentations on the implementation of the EU BSS directive in France, Belgium, Austria and Slovakia. Four posters were also presented on aspects not directly related to radiation protection measures at workplaces but dealing with various aspects relevant to developing regulation or to optimising radon exposures at the workplace.

The session showed that, even when the EU BSS directive provides a detailed framework for dealing with radon exposure at the workplace, there are still many challenges when implementing it in practice. Some examples were raised during the session: which are the criteria to be used for classifying areas with high radon concentration or whether a specific radon sign is needed; how to manage radon exposure for radiation workers from nuclear, radioactive facilities and NORM industries; how to ensure an adequate protection for itinerant workers; or, what the best approach is for radon dosimetry in tourist caves.

Workshop participants acknowledged that session the HERCA WG NAT can be of great help in dealing with these challenges, by exchanging experiences and sharing good practice. Examples of good practices presented during the session included the use of electronic tools to support regulatory oversight and compliance or the development of guidance documents on radon mitigation in buildings including case studies.

Challenges associated with the implementation of the new regulation on radon in workplaces: feedback from France

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The objectives of this presentation are first to summarize the main principles of the French regulation on radon management in workplaces enacted by the Decree No. 2018-437 of 4 June 2018 and then to highlight the main challenges raised by its practical implementation. The identification of these challenges comes from interviews conducted by CEPN in 2020 with different stakeholders involved in the management of radon risk in France (including General Directorate of Labour (DGT), IRSN, occupational risk prevention organisations, providers of radon measurement devices and employers).

The regulation is based on the desire to manage radon as any occupational risk, relying on the 9 principles of risk prevention. The responsibility for its implementation lies with the employer, and a graded approach to the management of this risk is adopted. The Figure below summarizes the radon risk prevention approach [1].

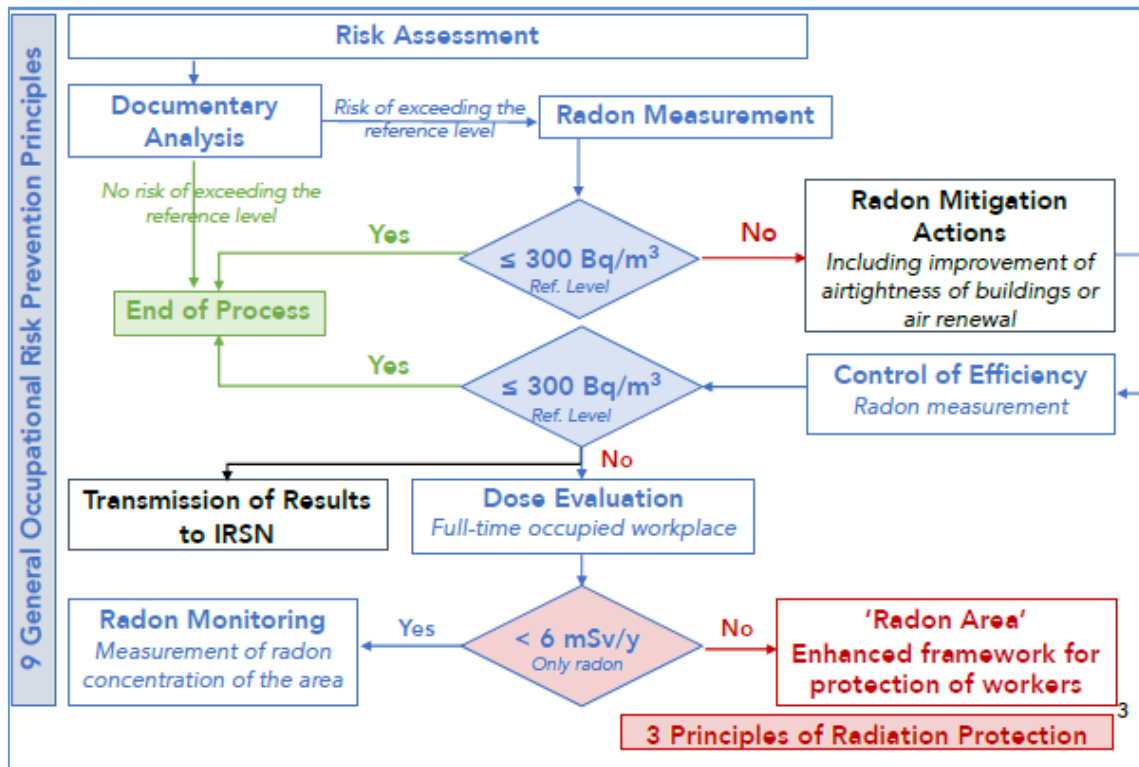


Fig. 4. Radon risk prevention approach.

It emerged from the interviews that this regulation is still unknown to many actors (ex. employers, safety at work inspectorates, ...) and that massive communication and training will be necessary to (re)inforce its application. Specific actions dedicated to information and support of employers have thus been introduced in the 4th National Radon Action Plan (2020-2024) and the 4th Plan on Occupational Health (2021 – 2024) [2, 3].

According to the result of the radon measurement and circumstances at the workplace, practical difficulties might be encountered by the employers at the different stages of the management process: from the 'documentary analysis' to the delineation and management of 'radon areas', including the measurement of concentrations over time, the building diagnosis and the remediation work.

The evaluation of the individual exposure (dose) of the workers is also a complex issue to deal with. Health risk issues cannot be neglected, and answers will need to be prepared and provided to meet the potential concerns from the workers regarding their past, current and future radon exposures.

From the interviews, it appears that there is a real need to develop assistance to employers, as the majority of them are not usually confronted with a radiological risk in their facilities. This assistance can take the form of practical guides (such as that of the DGT), or advice and support (technical, financial) from various organizations.

In the future, the collection of feedback from the various stakeholders involved in the practical implementation of this regulation will be essential to evaluate its effectiveness and adapt national action plans and/or the regulation itself.

References:

[1] *Direction Générale du Travail, Guide Pratique - Prévention du risque radon, 2020 (in French)*

[2] *Autorité de Sûreté Nucléaire, National action plan 2020-2024 for management of the radon risk*

[3] *Ministère du Travail, de l'Emploi et de l'Insertion, 4ème Plan Santé au Travail 2021-2025 (in French).*

The graded approach applied in radon preventive and protective measures of the Belgian National Radon Action Plan

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The Belgian National Radon Action Plan* defines the reference level for both dwellings and workplaces at 300 Bq/m³. Following a graded approach, optimisation has to be done both above and below the reference level, with a target level of 100 Bq/m³. Measurements are mandatory for workplaces in municipalities where more than 5% of the buildings exceed the reference level, and notification required when the reference level is exceeded. The notification can include a study to prove the compliance to the exposure limit of 600 kBq/m³, or a mitigation plan for reducing the radon levels well below the reference level. For dwellings, measurement campaigns for the general population are organised annually, with special attention for the higher exposed zones (with >5% of the buildings exceeding the reference level). Assistance in the mitigation procedure is provided for the dwellings exceeding 600 Bq/m³. In those higher exposed zones, radon protection is required for new buildings.

<https://fanc.fgov.be/nl/system/files/2020-06-belgian-national-radon-action-plan-2020-2025-en.pdf>

Austria: National Radon Action Plan and Regulation of Radon Protection in Workplaces

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In Austria, the protection against exposure from radon is already for many years part of the legal system. The latest provisions are laid down in the Radiation Protection Act 2020 (StrSchG 2020) and Radon Protection Ordinance (RnV), both published in 2020 in the frame of the transposition of the Euratom Basic Safety Standards Directive (2013/59/Euratom). In contrast to the previous provisions, radon protection at workplaces is not only mandatory for specific workplaces but also for all workplaces, which are located in ground floor or in basements in radon protection areas.

In 2021 the Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology established and approved the National Radon Action Plan (NRAP), which describes in particular the current status, need for action as well as responsibilities for eight subject areas of radon protection. The NRAP addresses long-term risks from radon exposures in dwellings, buildings with public access and workplaces. Many of the correspondent activities are already being carried out for many years. The purpose of the NRAP is to improve the coordination of those activities.

This contribution will provide an overview of the Austrian NRAP and present in more detail the Austrian regulation of radon in workplaces. In conclusion, the main challenge in Austria will be the practical coordination of many parallel activities in radon protection and to streamline risk communication in order to enhance transparency, effectivity and effectiveness in view to reduce the radon exposure in Austria.

The experience of the Slovak Republic with the dose assessment for tourist caves guides

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Keywords:

Dose assessment, radon, equilibrium factor, unattached fraction

Abstract:

The Slovak Republic has registered more than 7000 caves, 18 of them are open to the public. The Slovak Caves Administration manages 13 of them.

In 2019, as a result of the transposition the new Council Directive 2013/59/EURATOM, a new survey was carried out focused on the measurement of the radon activity concentration, the equilibrium factor and the unattached fraction in tourist caves under management of the Slovak Caves Administration. The measurement of the radon activity concentration was undertaken by the solid state nuclear track-etch detectors and the collection was from April to September 2019. The radon activity concentration was in the range of (50-10000) Bq/m⁻³.

The measurement of the equilibrium factor and the unattached fraction was carried out in the month of October – December 2019. The equilibrium factor ranged from 0.34 to 0.94 and the unattached fraction was 0.06 to 0.72.

Dose assessment was calculated for 168 tourist caves guides using ICRP 137 recommendation and the site-specific radon activity concentration, the equilibrium factor and the unattached fraction.

The Radon Protection Building Regulations in Spain

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This paper aims to describe the recent legislation (2019) for protection against exposure to radon in Spain's Building Code (Código Técnico de la Edificación, CTE).

The need to develop a regulatory framework on radon protection in buildings was prompted by recent awareness on exposure to indoor radon and the European Council mandate expressed in EU Directive 2013/59/EURATOM [1] to protect buildings from radon. Therefore, the Spanish Ministerio de Transportes, Movilidad y Agenda Urbana (Ministry of Transport, Mobility and Urban Agenda), in collaboration with the Instituto de Ciencias de la Construcción Eduardo Torroja (Eduardo Torroja Institute for Construction Sciences, IETcc), developed the new regulations taking into consideration protection against radon in buildings.

These requirements were included in the CTE in the document: Protección frente a la exposición al radón (Protection against exposition to radon, DB HS6) [2].

The main goal of these requirements is protecting people's health from the dangerous effects of exposition to indoor radon gas entering from the soil. They set a reference level of 300 Bq/m³ for radon concentration and describe several remedial or protective solutions for buildings according to two radon prone areas.

In order to support the application of the new regulations, due to the limited experience with technical solutions to radon protection in buildings in Spain, in 2020 was published the Guía de Rehabilitación Frente al Radón (Guide to radon remedial measures in existing buildings) which contains further details of the technical solutions to radon and real examples of mitigation in existing buildings including effectiveness achieved.

Translating radon awareness into action – the Irish experience

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While research shows that levels of radon awareness in Ireland are high at 82%, the number of people who take action is low. Typically, we see a 22% response rate to the offer of a free radon test and about 20% of householders with radon above the Irish reference level (200 Bq/m³) carry out remediation. A key priority of Ireland's NRAP is to translate radon awareness into action and so increase the number of homes that are both tested and remediated for radon.

To deliver on this, a National Communications and Advocacy Strategy for Radon was developed in 2016. This strategy captured and reflected the extensive experience gained and lessons learned about radon risk communication and behavioural change, both nationally and internationally. The lessons learned and how they have informed subsequent radon risk communication will be presented.

In addition, a health psychology review of EPA radon awareness campaigns was carried out. This review advise that the State has an important role to play in managing the risk from radon. It recommends that increased governmental regulation, supported by financial incentives, combined with high quality information programmes are required to significantly increase the rate of testing and remediation. A further recommendation is that radon risk communication is targeted to particular audiences. Progress made to date on these recommendations and challenges encountered will be discussed.

Data-driven classification of bedrocks by the measured uranium content using Selforganizing maps

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Uranium is a naturally occurring element that can be found almost everywhere in rocks and soils throughout the earth's crust. One of its decay products, radon, is of gaining concern in recent years because this colourless, odourless, tasteless gas is proven to be

responsible for many lung cancer cases each year. Analysing the spatial distribution of the uranium concentration in the ground surface can help predicting radon hazard regions. In this study, two types of uranium measurements – the airborne gamma-ray spectrometry (AGRS) and the ground-based rock sample analysis via inductively coupled plasma mass spectrometry (ICP-MS) – are calibrated for the purpose. The two types of data with different sampling schemes are found to have a reasonable correlation to each other when using the mapped geology as categorical units. This finding confirms the feasibility of using geological maps as a first-order predictor to map uranium, and further radon, in a larger scale. We then apply the self-organizing maps (SOM) technique for a data-driven classification of rock types based on the measured uranium content. The presented study area is located at mid-Norway in the Trøndelag county, same study will be performed in other regions across Norway where both types of measurements are in abundance. This study contributes to an on-going project to map radon hazard zones of the entire Norway. While the radon hazard is defined by the indoor radon level which is affected by two folds of factors – geogenic (uranium-rich subsurface) and anthropogenic (dwelling type, indoor air exchange, etc.), our work aims to first single out the geogenic factor. Comparing to the current national Radon Awareness Map of Norway (URL: <http://geo.ngu.no/kart/radon/>), where bedrocks were categorized by their likelihood of hosting elevated indoor radon, our approach utilizes measured uranium concentration of the ground which has a more direct link to the bedrock types.

Indoor radon risk assessment in mainland Portugal

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Council Directive 2013/59/EURATOM establishes the basic safety standards (BSS) in radiation protection transposed, in Portugal, through the Decree-Law 108/2018, of December 3, which states that exposure to radon in workplaces, homes and other public buildings should be assessed and a national plan be developed. For this purpose, a key tool is a radon risk map, usually drawn from indoor radon concentration (IRC) data, which, in the case of Portugal, were not available in many areas of the country. So, as a first step, an inventory of the available IRC data allowed to identify areas where data

were scarce or unrepresentative of the size of the population and/or the geological bedrock substrate. A national indoor radon survey was then conducted during which 2202 measurement values were obtained and the final IRC database was composed of 3084 results. Metrological consistency was ensured for all results given they were acquired through the same method based on ISO 11665-4:2012 using CR-39 passive detectors and by the same entity, namely the Laboratory of Natural Radioactivity of University of Coimbra. To further assess indoor radon risk, complementary existent data from commonly used IRC proxies such as soil gas radon concentration (SGRC), uranium (U) and radium (Ra-226) concentration in rock samples, and the terrestrial gamma dose rate (TGDR) were also gathered and analyzed.

A state of the art of possible methodologies to map the risk of exposure to indoor radon was developed, assessing their advantages and drawbacks. It was concluded that the best method to draw the radon risk map should have as a principle to maximize the use of all the available information, the IRC and the other databases. Although coherent with each other as shown by the strong positive correlations with the median IRC by geological unit, the databases were considered fragmentary, being characterized in most cases by a low sampling density and incomplete coverage of the national territory. The application of geostatistical methods using available data was also considered limited due to the nature of some databases, where the location of the samples was either unknown or only approximately known.

In view of the previous limitations, a simple binary classification method was chosen to identify the areas where an increased exposure to radon was expected. A given area (corresponding to a geological unit) was classified as having a high risk of exposure to indoor radon when the expected IRC exceeded the national reference level (NRL) of 300 Bq/m³ in at least 10% of the buildings in that area. The binary classification systems were trained for each proxy (SGRC, U and Ra-226 concentration in rock samples, and TGDR) by analyzing the Receiver Operating Characteristic (ROC) curve and a risk index was developed to make use of all available information for any geological unit. Finally, to produce the radon risk map, geological units were categorized according to the risk index in three levels. In this work, data are presented, the methods, challenges and the resulting indoor radon risk map are discussed.

Romanian National radon monitoring – related metrological infrastructure for the calibration of commercial radon monitors

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The implementation of the European Basic Safety Standard Directive (2013/59/EU) requires traceable metrological resources (calibration and measurement) for the monitoring of radon, not only for the indoor radon but, in a broader context, also for outdoor environmental measurements, considering that the indoor radon concentration is strongly influenced by the radon concentration in the soil.

In this regard, the Ionizing Radiation Metrology Laboratory (LMRI) from IFIN-HH (the holder of the National Standard for the activity of “a radionuclide” status), has been involved in recent years in a number of projects that contribute to the creation of metrological infrastructure for radon suitable for the requirements of the Radon Action Plan requested. Thus, the JRP 16ENV10 MetroRADON **“Metrology for radon monitoring”** aimed to establish the traceability chain in measuring the indoor radon concentration, in the range of 100 - 300 Bq / m³, by developing new radioactive reference sources with stable and known radon emanation capacity in order to calibrate radon measurement instruments traceable to primary standards, comparison and harmonization of radon measurement procedures.

The practical implementation of the European Council Directive no. 2013/59/EURATOM in Romania requires reliable indoor measurements of the radon (Rn-222) activity concentrations in air. In Romania, several Testing Laboratories were designated for radon activity and/or radon activity concentration in air measurements by the Romanian National Commission for Nuclear Activities Control (CNCAN). The calibration of the instruments used for indoor radon activity concentration measurements is very important. IFIN-HH, through LMRI, performed advanced research in the field of radon metrology, using self-developed radon standard sources, its radon chamber facility and a new reference radon monitor. The most recent results are described in this article. The radon chamber facility from IFIN-HH was technically improved, and new equipment and methods and protocols were set up and tested/validated in order to provide new calibration services for customers. Additionally, calibration of the radon monitors was performed, as well as of the solid-state nuclear track detector -based systems, used for radon in air activity concentration measurements. IFIN-HH/LMRI obtained the CNCAN designation as Calibration Laboratory for installations measuring the radon activity concentration in air.

IFIN-HH/LMRI is continuously extending and widening its radon monitoring -related capabilities through its involvement in various relevant ongoing R&D research projects such as JNP EMPIR 19NET03 support BSS **“Support for a European Metrology Network on reliable radiation protection regulation”** (having as main objective to develop a plan for a joint and sustainable European metrology infrastructure underpinning radiation protection regulation) or JRP EMPIR 19ENV01 traceRadon, **“Radon metrology for use in climate change observation and radiation protection at the environmental level”** which is aiming to use radon as tracer to evaluate dispersal models for identifying successful greenhouse gas (GHG) mitigation strategies; to increase the accuracy of both radiation protection measurements and those used for GHG modelling, traceability to SI units for radon release rates from soil, its concentration in the atmosphere and validated models for its dispersal. The overall aim of this project is the development of metrological capacity (reference monitors, transfer standards and robust methodology) to measure low levels of radon in the environment, which can be used to determine emission reduction strategies of GHG and improve radiation protection of the general public.

6. Communication and Stakeholder engagement

Communication and stakeholder engagement are essential for a successful radon risk management in the NRAPs.

The development of a communication strategy taking into account cooperative involvement of the stakeholders, the development of information that is targeted and adapted to different audiences and the involvement of diverse partners for a co-ordinated and consistent communication brings several benefits, mainly in the acknowledgment and perception of the risk.

The purpose of this session is to present and discuss communication strategies that different countries have adopted and to give examples of practical aspects and outcomes of their implementation.

The speakers in this session presented the strategy and plans for communication and stakeholder engagement that are been developed in the different countries. They showed the ways and means of communication that are being used, how they measure the effectiveness of communication and stakeholder engagement, the lessons learned from successful cases and from those that did not have the desired impact.

Communication and stakeholder involvement in national radon action plans: overview of on-going practices in EU MS and the UK

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After transposing and implementing the 2013 Basic Safety Standards Directive, EU Member States have to develop and implement communication and stakeholder engagement strategies to increase public radon awareness. This entails that EU Member States (MS) are legally required to increase public awareness and inform local decision makers, employers and employees of the risks of radon, including in relation to smoking. Moreover, EU MS shall provide as appropriate for the involvement of

stakeholders in decisions regarding the development and implementation of strategies managing exposure situations.

The EU-RAP project, funded by DG Energy and with the collaboration of the EU-RAP Reference Group, have developed a methodology to assess the strategies and the practical implementation of the actions defined in radon action plans (RAP) including communication and stakeholder involvement. Firstly, the consortium systematically analysed the content of the national RAP's to investigate how communication and stakeholder engagement aspects are planned to be addressed. Secondly, group interviews with relevant authorities in all EU MS and the UK were conducted in order to check whether our interpretation of national legislation was correct or needed to be modified. In addition, these interviews also focused on the practical implementation of communication and stakeholder involvement, as well as other elements in Annex XVIII. Finally, four regional workshops were organised to understand countries' specificities regarding radon awareness campaigns, and to discuss the challenges in communication and stakeholder involvement. All the activities were conducted from March 2021 until May 2022.

Results show that the prime goal of communication campaigns is educating people and raising awareness, although current studies in communication science show that radon awareness only has a limited effect on testing and mitigating behaviours. We found that communication activities are mainly designed based on gut feelings, and are less theory- and evidence-based. Only few MS engaged communication experts to help authorities in preparing the communication strategy and only two MS investigated a baseline of existing knowledge, attitudes, views and behaviour related to radon mitigation in populations under radon risk, using a methodologically sound approach (i.e. clear and representative sampling, data collection, analysis and interpretation of data). There are four MS which had the possibility of benefiting from data obtained through a dedicated IAEA STEAM project, but some years after collecting data, those are still not analysed and could not be used timely for designing an informed communication strategy.

A detailed and functional communication plan/strategy is still not developed in all MS. A wide range of stakeholders are identified in written plans, but in practice, mostly three categories are involved: the general public (in all MS), building industry (in most MS) and local decision-makers (in few MS). There are some good practices found in MS related to the use of communication channels as emerging and evolving communication technologies, such as social media. These offer the possibility of improved radon risk communication, because these technologies have the potential for increased information capacity, reliability and interactivity. Moreover, specific websites on radon are available or foreseen in the majority of the countries with high radon prone areas.

However, MS may be challenged with evaluation of efficiency of communication activities and consequent improvement of communication plans. Most of them do not foresee any efficiency test, such as regular public opinion polls, follow-up of the evolution of measurements and/or mitigation actions after communication campaigns, systematic collection and reach out of media articles, content analysis of social media discourse, etc.

These results, collected by the EU-RAP study, will be presented with more details and in the context of up-to-date and evidence-based recent communication research results from the RadoNorm project. The presentation is of benefit for all authorities responsible for radon communication and other agencies dealing with radon risk management, since radon communication is complex and communicators need to address how communication can help to increase the number of tests and mitigation actions if needed.

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Luxembourg's National Radon Action Plan

Marielle Lecomte

MS, Luxembourg

With the implementation of the first National Radon Action Plan from 2017 onwards; Luxembourg's radiation protection authority (DRP) has been able to substantially raise awareness about radon exposure in dwellings, e.g. through the distribution of flyers to all households, an updated website and information sessions fostering direct discussion with the population. The identified radon zone comprises the northern 5 cantons of the country. More than 5 up to 30% of the dwellings of that region show average indoor radon concentrations above the reference level of 300Bq/m³. The DRP offers free radon tests to all households and consults on remediation. Different remediation techniques have shown positive effects on lowering radon concentrations, with sub-slab depressurization giving by far the best results. In some regions, the DRP has already done measurements in up to 10% of the dwellings, giving rise to a rather comprehensive database. This has been used to make average results public available through www.geoportail.lu. The DRP could also show that average radon concentrations have

increased over the last 20 to 30 years. A specific study on new-build houses has given evidence that modern building techniques consisting on improved insulation, combined with a double-flow ventilation result in radon concentrations well below the reference level. Another study on seasonal variations showed no evidence for a clear seasonal factor. With its first National Action Plan ending 2020, Luxembourg has recently issued its second edition. The new radon action plan covers the years 2021 to 2028 and is a continuation of the first action plan with additional focus on workplaces.

The Norwegian experience by regulating radon – communication and public awareness

Maria Larsson

Norwegian Radiation and Nuclear Safety Authority (DSA)

In Norway, the introduction of two new regulations with legally binding limit values for indoor radon concentrations has contributed significantly to the public knowledge of radon. The regulations are a result from the work on the national radon strategy, adopted by the Norwegian government in 2009. The strategy was evaluated and updated in 2014. The regulations in question are New build (2010) and Schools/kindergartens and rental accommodations (2014). The legally binding limits are 100 Bq/m³ (action level) and 200 Bq/m³ (maximum level).

Radon regulations in Norway

The introduction of the new regulations has been essential for DSA's communication work. The increased attention from the media has been an important contribution to this. In addition, DSA has provided general information to the public, as well as customized information for specific target groups affected by the regulations. As a result, we have noticed a significant spin-off effect among people in general, property managers, local authorities as well as radon professionals. Population surveys, conducted on a regular basis, show for example that more homeowners measure radon after the introduction of the regulations, compared to before. The combination of information about radon and a mandatory approach on certain areas seems to be effective. The presentation will discuss the lessons learned and future challenges.

Seven years with radon susceptibility map in Norway: a review of what we achieved and what we learned

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People in Norway have a natural affinity with the beautiful landscape and pristine nature in their country, which contributes to a general interest in geology and the knowledge of radon gas is multi-present in the public. To a large extent the landscape of Scandinavia was shaped by glaciers and particularly in Norway most of the sedimentary strata was eroded down to the bedrock. Therefore, among the Norwegian population there is a general awareness that due to this landscape evolution a natural shield from uranium containing bedrock as a source for formation of radon gas is missing in large parts of the inhabited areas.

During the last decades, several studies and programs were carried out all over the country by the Geological Survey of Norway and the Norwegian Radiation and Nuclear Safety Authority comprising geological mapping of uranium content in bedrock and soil as well as radon measurements in dwellings to map and quantify the radon risk in Norway. But it was not before 2014 a general radon map for Norway was published. The map was based on the gained knowledge on uranium-containing bedrock and soil, the 1:250.000 bedrock map, 1:50.000 to 1:1 million quaternary map for Norway and the comprehensive radon inhouse measurement database for Norway. The datasets were statistically compiled to develop a nationwide radon susceptibility map. Although the radon measurements from dwellings were sparsely distributed with higher density in populated areas and only a few or no data in smaller towns and remote areas, the final product reflected the major distribution for radon risk in Norway. Although the geological maps contained bedrock information for the entire country, we used a careful correlation process to exclude a radon susceptibility value from specific areas where we could not get a reliable coverage.

When published, the map gained almost instantly quite large attention and was used by counties and municipalities all over Norway for areal planning, but also in large infrastructure projects like railroad and road constructions. Real estate brokers even used it to give additional information about houses and promoting building lots. Even private people consulted it quite extensively to check radon susceptibility at their property or potential new homes.

The map turned out to be a long-expected product, which is frequently used. However, we learned that the way-to-read and the limitations of the map were not communicated good enough. Supplementary information was hardly noticed by users and people were applying it to purposes far beyond the resolution of the map. Subsequent feedback from users, which measured radon concentration in dwellings, but in particular new comprehensive airborne uranium data revealed locally inaccuracies and erroneous radon susceptibility information and disclose the need for a more advanced updated version of a radon map.

We will present the new strategy for an updated radon map for Norway which is currently under development. The strategy comprises not only a map, but also a dissemination plan to advert to the complexity of the radon susceptibility assessment.

Implementation of radon strategies in Austria – experiences, challenges, benefits

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Austria, as a country with a high geogenic radon potential, has been carrying out coordinated radon activities already since the early 1990s. Even if there was a lot of experience already available in the country, new requirements and challenges arose with the publication of the European Basic Safety Standards (EU-BSS) in 2014. The main tasks were to integrate the topic “radon at (general) workplaces” in the legal regulations, to delineate radon priority areas and to establish a national radon action plan. The new radon legislation was published in 2020, the radon action plan in 2021.

In this contribution, the experiences, challenges and results of the latest radon activities in Austria will be presented. Special focus will be given to the national radon survey (2013-2019, measurements in about 30,000 dwellings), the delineation of radon areas and the new radon map, including the consequences for the population and the employers. In addition, first insights of advantages and challenges with the implementation of the new radon regulation will be given.

New developments in the EURADOS WG 3.3 “Radon”

Annette Röttger

EURADOS Chair of WG 3.3 “Radon”

Head of the Division of Ionizing Radiation, PTB, Germany

In 2018 the subgroup “Radon” was formed under the umbrella of Working Group 3 “Environmental radiation monitoring” in the European Radiation Dosimetry Group (EURADOS). Due to the importance of this issue, EURADOS decided to dedicate its entire Winter School in 2019 to different aspects of radon, as there are radon dosimetry (ICRP lung model and microdosimetry), lung cancer risk (epidemiological studies), respective standards and regulations, metrology of radon and radon progeny, measurement campaigns and the use of radon as an atmospheric tracer [1].

The ongoing discussion of the special needs of scientists working in the field of radon resulted to an extension of the EURADOS Strategic Research Agenda to improve environmental monitoring for radon and to develop and adapt infrastructures for calibration and comparison exercises using novel environmental technologies. This is a need that requires a joint effort of metrology institutes, calibration services standards development organisations and must include the needs of national and international bodies. Considering this large group of stakeholders the topic was included in the proposal for an EMPIR networking project¹, which received funding in 2020. As a result a European Metrology Network (EMN) for Radiation Protection and was established under the roof of EURAMET in 2021 <https://www.euramet.org/european-metrology-networks/radiation-protection/>. EURADOS joined the EMN-RP as a partner.

Parallel to this development in radiation protection, the outdoor radon activity concentration and the flux from radon from the ground to the atmosphere provides important information on greenhouse gases (GHG) and helps to identify Radon Priority Areas (RPA) simultaneously. It was observed that an overlapping need exists between the climate research and radiation protection communities for improved traceable low-level outdoor radon measurements. The aim is to provide easy to use dynamic radon and radon flux maps for climate change research and radiation protection in line with Council Directive 2013/59/EURATOM, including their use to identify RPA (EMPIR project 19ENV01 traceRadon¹). The necessary metrological infrastructure will be set up in the coming three years in the scope of this project <http://traceradon-empir.eu/>.

The EURADOS strategy is reflected in the aims in both EMPIR projects, while EURADOS members are active contributors to support metrology in the field of radon. In

consequence, this contribution aims to provide information about the recent metrological developments, summarizes future possibilities and can help to establish regular, constructive dialogue and liaison between EURADOS WG 3.3, both projects and HERCA.

¹ This project 19ENV01 traceRadon has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

7. Working Groups and Round Table Discussions

A major aim of the workshop was to provide a platform for sharing experiences and discussing important issues regarding NRAPs. For this reason, a session with three working groups and round table discussions was organised. One working group was held virtually to allow remote participants to participate.

All three working groups had the same topics to work on; a handout with questions on the following three topics was provided to the groups:

- Indicators
- Rn at workplaces
- Rn in building codes

The chairs and rapporteurs presented the results of the working group discussions after the working group session.

The working group who met virtually covered indicators topic only.

7.1. Indicators of effectiveness of NRAP – round table discussions

During the break-out sessions, three working groups discussed the 14 indicators that were included in the HERCA questionnaire circulated before the meeting.

- Number of measured dwellings/workplaces used to estimate radon levels
- Number (and %) of municipalities / regions with a reliable estimate of indoor Rn levels
- Number of persons living in municipalities / region with a reliable estimate on Rn levels
- Estimated number (and %) of dwellings/workplaces with Rn level > R

- Number (and %) of identified dwellings/workplaces with Rn level > RL
- Remediation rate over the RL (i.e. the number of remediated dwellings compared with the estimated number of dwellings/workplaces exceeding RL)
- Number of remediated dwellings/workplaces with initial Rn level below the RL (in case remedial actions are recommended also below RL)
- Number (and %) of new buildings with preventive measures against Rn
- Number of periodic courses (including refresher courses) on radon remediation and prevention in dwellings/workplaces
- Number of available qualified experts/services for radon remediation and prevention in dwellings/workplaces
- Number of contacts to web sites (and other social media) containing information on radon protection in dwellings
- Any indicator of the overall reduction of radon exposure in dwellings/workplaces
- Estimated number (and %) of lung cancers that will be avoided thanks to the exposure reduction in dwellings/workplaces
- Availability of national database(s) to collect data and information to estimate the overall impact in dwellings/workplaces.

Intensive discussions in all three groups led to concluding remarks that countries have different understanding and approaches to some of the discussed indicators, more work is needed on the indicators with respect to collection and analysis of data needed for their development, methodology. It was well noted that each different country may have a different approach to which indicator may be useful in her case, i.e. in prevailing national conditions and actions included in the national action plan.

HERCA WG NAT does not have an intention to work on harmonization in order to provide a unique Indicators list that would be promoted in the HERCA member countries, but will further exchange on useful indicators that already are in use in some of the countries or identify those that seem to be useful in practice.

7.2. Radon at workplaces – round table discussions

The main issues discussed were the use of the dose coefficient, the consequences of applying the ICRP 137 dose coefficient, the classification of workplaces as planned exposure situations, the requirement for registration, notification or licensing as well as the implementation of the requirement for optimization even if the radon level is below the reference level.

To summarize, only a few countries still apply the ICRP 65 dose coefficient, and the majority uses ICRP 137 (however, a couple of countries do not apply ICRP 137 for tourist caves). If the dose exceeds 6 mSv/y notification is required.

Regarding optimization below the reference level, this is mainly an issue in case of remediations where the goal is to reduce the radon level well below the reference level.

7.3. Rn in building code – round table discussions

Regarding building codes, the aim was to share experiences in implementing building codes for new buildings.

In many countries, building codes require preventive measures for new buildings. In a few countries preventive measures are recommended.

Interestingly, in about half of the countries with the obligation to implement preventive measures in new buildings, this applies to the whole countries whereas in the other countries it applies only to radon priority areas. In some countries with a nationwide obligation there is a graded level of protection depending on if the new build is located in a radon priority area or not.

8. Topics for future work on Radon in HERCA member states

HERCA WG NAT identified and included radon topics of relevance for HERCA member countries in its own Action Plan (2021-2024) as follows:

1. To exchange information about national regulations with regards to the implementation of specific BSS directive requirements on radon, NORM and building materials.
2. To organise the postponed (due to Covid-19 pandemic in 2020 and 2021) follow-up workshop on National Radon Action Plans (NRAP), including an online pre-workshop event on that topic.
3. To continue to explore more specific issues within the topic of Radon
 - The application of a graded approach and of the optimization principle for the regulation of radon at workplaces

- Effectiveness of radon control actions, including indicators regarding radon in workplaces and dwellings
- Integration of radon with general requirements on indoor air quality

The further work and exchange in HERCA WG NAT will continue on points 1 and 3.

However, in order to better prepare here presented workshop, a small exercise was done with workshop participants to obtain their views and proposals for radon topics that, in their opinion, need more consideration and evaluation in future, at the international level. During the workshop, it was also observed that significant overlapping exists with results of this exercise and topics discussed or highlighted in the specific national presentations. Therefore, the exercise results - radon topics - were presented in the final workshop session:

- Effectiveness Indicators for NRAP activities - identification of key indicators/metrics, what works well for majority of countries, planning and conducting regarding the specific conditions of the country and its NRAP, what activities and resources are needed, challenges, good practices and lessons learned
- Radon measurement procedures, monitoring and data bases
- Radon and building regulations
- Radon in workplaces
- Radon and risk communication

Although some of the topics listed here are already included in the working plan of HERCA WG NAT, it should be highlighted that since the list is quite comprehensive (given here in compressed version), HERCA WG NAT WP Radon will in future work focus on chosen topics, e.g., exchange on developed national indicators for measurement of effectiveness and radon optimization at workplaces, while other topics could potentially be discussed in form of national presentations and exchange through discussions.

9. Conclusions

Five main sessions, each dedicated to a specific radon issue, and roundtable discussions were held in three workshop days. Intensive exchange in form of questions and discussions by the participants followed each of the workshop sessions. It was a unique opportunity to share national and international views and to exchange challenges, constraints and achievements concerning different aspects of the complex radon issue. During the closing session, concluding remarks from the workshop were presented and are summarized here.

Radon is a public health risk, and with respect to the main objectives of the workshop, the status of international and national activities for radon level and exposure reduction was presented. EC, IAEA and WHO presented an updated status on radon related activities. National Radon Action Plans in Europe are developed and implemented in the HERCA member countries, with different activities included. In many countries the focus is currently on more specific elements of the NRAP, such as the improvement of radon measurement procedures, the evaluation of the effectiveness of measures in the NRAP through the development of effectiveness indicators, an effective regulatory approach to radon control in workplaces as well as communication and perception of radon risk.

Comparing to the outcome from the first NRAP workshop, held in 2014, a significant improvement in many aspects of radon exposure control/reduction in various countries was observed. It was highlighted that the cooperation between different sectors at international, national, regional and local levels is an imperative for success in implementing the national strategies for radon.

Main elements identified in the NRAP of different HERCA countries

- Country radon maps are available in majority of countries – valuable tools, but caution is needed in their interpretation
- Control of existing exposure in public buildings and dwellings is ongoing, but there is room for further improvements, for example considering:
 - Public awareness and proactive attitude
 - Measurements campaigns, information availability, guidelines
 - Voluntarily and mandatory actions (public buildings)
 - Financial incentives and positive impact on remediation
- Radon measurement protocols should be further improved with respect to:
 - Method, period (season), time, location - screening phase, control and follow up phase

- Self-test – should be followed by the exact measurement protocol and proper control of adequacy of procedure, employers' responsibility
- Accredited measurement services
- Preventive measures for radon in new buildings are proved to be cost efficient in radon reduction
 - Rn in building codes is an important measure (binding requirement in some countries)
- Need for further information dissemination and providing training and education of professionals to improve expertise of:
 - Building professionals
 - Remediation experts

Workplaces – regulatory process with graded approach and use of optimization principle

- Obligation to measure (certain workplaces and country areas), remediation and optimization where needed, control measures and inspections are measures that are highly relevant to have an optimized regulatory approach for radon control at workplaces
- Improved radon measurement protocols for workplaces are needed
- Introduction of mandatory activities (like measurement of radon levels in specific building types) versus previously adopted voluntarily approaches
- Different approaches to use of updated radon dose coefficient use are observed:
 - National decisions, but important to continue exchange on challenges and solutions
- Remediation and Optimisation activities – different approaches are presented

Communication and stakeholder engagement related to NRAP

- It was highlighted as a good practice having shared responsibility between stakeholders – communication between authorities, but also professionals, public groups, end users

- Communication strategies not always defined at national levels, but many national communication actions implemented through different communication channels – press releases, radon days, leaflets for schools, social media etc.
- Raising awareness of importance for all countries; focus has to be on behavioural change -> importance to exchange and learn from existing examples, professionals
- Communication plans with well-defined target groups, communication channels, multipliers are needed
- Continuous, repeated communication required
- Radon is not an attractive topic that is easy to communicate
- Combination of mandatory regulation and repeated communication seems to be effective

Indicators for NRAP

- List of indicators useful, but selection and applications depend on national circumstances
- There is a need for a description of what input data are required
- Prerequisite: Comprehensive national data base including data from dwellings and workplaces; radon levels (measurement period, measured room, floor level etc.), radon exposure, building characteristics, preventive measures (yes/no, type), remediation measures (type)
- HERCA WG NAT will not endorse any of the discussed effectiveness indicators as these may be quite different depending on countries' prevailing circumstances, available resources, etc. It is concluded that, at the moment, there is no need for a harmonized European list. Instead, the exchange about indicators, and selection of one – two indicators that can be more thoroughly discussed within WG NAT, will be continued in coming meetings.

To conclude, the workshop was seen to be very encouraging. It gave the opportunity to share knowledge, experiences, successes, and failures. There was a frank and benevolent exchange between the participants which allowed to learn from each other.

Acknowledgment

The contribution and work presented by WG NAT participants and corresponding national and international authorities are highly appreciated. The Organizing Committee of the HERCA 2nd NRAP workshop would like to thank the HERCA Board for their support during the preparation of the workshop.

Finally, we would like to acknowledge the contribution and support of the national authorities of Portugal and Norway, APA and DSA, respectively.

Annex I. Workshop programme

2nd HERCA Workshop on National Radon Action Plans

21 - 23 JUNE 2022 | VENUE: PORTUGUESE ENVIRONMENT AGENCY (APA), LISBON – PORTUGAL

Day 1

9:00 – 9:20	Welcome & Official Opening Ana Teresa Perez (APA, Portugal) An introduction to the 2 nd NRAP workshop, Jelena Mrdakovic Popic (DSA, Norway)
International organizations Chairpersons: Jelena Mrdakovic Popic (DSA) Benjamin Klein (BMUV)	
9:20 – 9:40	EC activities on radon and on national radon action plans, Stefan Mundigl (EC)
9:40 – 10:00	Results of the IAEA's 5 years project aimed to support the MS in development and implementation of National RAP, Olga German (IAEA)
10:00 – 10:20	National Radon Action Plans: A global public health perspective, Emilie van Deventer, (WHO)
10:20 – 10:40	Radon mapping of a different kind: Mapping activities and collaborations on radon of international organizations and associations, Wolfgang Ringer (AGES, Austria)
10:40 – 11:00	Coffee break
National Radon Action Plan/indicators Chairpersons: Wolfgang Ringer (AGES) Marcela Bercikova (SUJB)	
11:00 – 11:20	Results of questionnaires on indicators, Francesco Bochicchio (ISS, Italy)
11:20 – 11:40	Assessing the effectiveness of Radon Action Plans: searching for a systematic and standardised method, Meritxell Martell (MERIENCE, Spain)
11:40 – 12:00	Indicators and Targets in Ireland's NRAP, David Fenton (EPA, Ireland)
12:00 – 12:20	Performance indicators in the radon action plan of Finland, Päivi Kurttio (STUK, Finland)
12:20 – 12:40	Assessing the impact and effectiveness of the Norwegian Radon Strategy, Bard Olsen (DSA, Norway)
12:40 – 13:50	Lunch break
National Radon Action Plan general Chairpersons: David Fenton (EPA) Daniela Dogaru (CNCAN)	
13:50 – 14:10	The development of the Portuguese NRAP, Heloisa Fonseca (APA, Portugal)
14:10 – 14:30	Swiss National Radon Action Plan 2021-2030, Fabio Barazza (BAG, Switzerland)
14:30 – 14:50	The 4 th French national action plan for management of the radon risk, Anne Jegouzo (ASN, France)
14:50 – 15:10	The United Kingdom Experience of Creating its First National Radon Action Plan, Tracy Gooding (UKHSA, UK)
15:10 – 15:30	Radon action plan of the Czech Republic, Marcela Bercikova (SUJB, Czech Republic)
15:30 – 16:00	Coffee break
16:00 – 16:20	Implementation of the radon national action plan in Romania - Status and Perspectives, Daniela Dogaru (CNCAN, Romania)
16:20 – 16:40	National Radon Action Plan in Slovenia, Damijan Skrk (URSVS, Slovenia)
16:40 – 17:00	Protection from Radon in existing residential buildings in Germany, Benjamin Klein (BMUV)
17:00 – 17:20	Poster Presentations Towards the Italian National Radon Action Plan, Anna Balsamo (MS, Italy) National Radon Action Plan in Hungary, Zsolt Homoki (NNK, Hungary) CSN Activities in the frame of the 1 st National Radon Action Plan of Spain, Gonzalo Valles (CSN, Spain) National action radon plan of the Slovak republic, Kristina Zemkova (UVZSR, Slovakia) Draft Document Radon Action Plan in the Republic of Serbia, Vladimir Udovicic (IPB, Serbia)
3 min presentation for each poster	
17:20 – 17:40	Questions to speakers and discussion, Francesco Bochicchio (ISS, Italy) & David Fenton (EPA, Ireland)
18:00 – 19:30	Cocktail at APA

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Day 2

Radon at the workplace		Chairpersons: Marta García-Talavera (CSN) Stefan Mundigl (EC)	
9:00 – 9:20	Challenges associated with the implementation of the new regulation on radon in workplaces: feedback from France, Sylvain Andresz (CEPN, France)		
9:20 – 9:40	The graded approach applied in radon preventive and protective measures of the Belgian National Radon Action Plan, Boris Dehandschutter (FANC, Belgium)		
9:40 – 10:00	Austria: National Radon Action Plan and Regulation of Radon Protection in Workplaces, Beatrix Schoenhacker-Alte (BMK, Austria)		
10:00 – 10:20	The experience of the Slovak Republic with dose assessment for tourist caves guiders, Alžbeta Ďurecová (VZBB, Slovakia)		
10:20 – 10:40	Poster Presentations		
3 min presentation for each poster	The Radon Protection Building Regulations in Spain, Pilar Linares-Alemparte (IETCC, Spain)		
	Translating radon awareness into action – the Irish experience, Alison Dowdall (EPA, Ireland)		
	Data-driven classification of bedrocks by the measured uranium content using Selforganizing maps, Ying Wang (NGU, Norway)		
	Indoor radon risk assessment in mainland Portugal, Alcides J. S. C. Pereira (LRN, Portugal)		
10:40 – 11:10	Coffee break		
Communication and stakeholder engagement		Chairpersons: Boris Dehandschutter (FANC) Heloisa Fonseca (APA)	
11:10 – 11:30	Communication and stakeholder involvement in national radon action plans: overview of on-going practices in EU MS and the UK, Tanja Perko (SCKCEN, Belgium)		
11:30 – 11:50	Luxembourg's National Radon Action Plan, Marielle Lecomte (MS, Luxembourg)		
11:50 – 12:10	The Norwegian experience by regulating radon – communication and public awareness, Maria Larsson (DSA, Norway)		
12:10 – 12:30	Seven years with radon susceptibility map in Norway: a review of what we achieved and what we learned, Marco Brønner (NGU, Norway)		
12:30 – 12:50	Implementation of radon strategies in Austria - experiences, challenges, benefits, Valeria Gruber (AGES, Austria)		
12:50 – 13:10	New developments in the EURADOS WG 3.3 "Radon", Annette Röttger (EURADOS)		
13:10 – 14:10	Lunch break		
NRAP general + indicators		Working groups - round table discussions	
14:10 – 14:20	Introduction to the working group session, Francesco Bochicchio (ISS, Italy)		
14:20 – 15:30	Working group 1 Chair & Rapporteur: Francesco Bochicchio, Fabio Barazza	Working group 2 Chair & Rapporteur: Wolfgang Ringer, Boris Dehandschutter	Working group 3 Chair & Rapporteur: David Fenton, Alison Dowdall
15:30 – 16:00	Coffee break		
16:00 – 17:00	Working group 1, Chair & Rapporteur: Francesco Bochicchio, Fabio Barazza	Working group 2, Chair & Rapporteur: Wolfgang Ringer, Boris Dehandschutter	Working group 3, Chair & Rapporteur: David Fenton, Alison Dowdall
17:00 – 17:30	Questions to speakers and discussion, Marta García-Talavera (CSN) & Heloisa Fonseca (APA)		

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Day 3

Results of the working groups discussions	
9:00 – 9:10	NRAP general + indicators, Francesco Bochicchio (ISS, Italy)
9:10 – 9:20	NRAP general + indicators, Wolfgang Ringer (AGES, Austria)
9:20 – 9:30	NRAP general + indicators, David Fenton (EPA, Ireland)
9:30 – 10:30	Discussion and conclusions, Jelena Mrdakovic Popic (DSA, Norway) & Heloisa Fonseca (APA, Portugal)
10:30 – 11:00	Coffee break
Future topics for HERCA WG NAT	
11:00 – 11:15	Proposal and discussion of future topics, Jelena Mrdakovic Popic (DSA, Norway)
11:15 – 11:30	Workshop conclusions Jelena Mrdakovic Popic (DSA, Norway) and Wolfgang Ringer (AGES, Austria) Closing of the workshop

Annex II. List of participants

Participant	Organisation	Country
Alar Polt	Republic of Estonia Environmental Board	Estonia
Alcides Pereira	University of Coimbra	Portugal
Alison Dowdall	Environmental Protection Agency	Ireland
Alzbeta Durecova	Regional Public Health Authority in Banska Bystrica	Slovak Republic
Ana Getaldić	Ministry of the Interior Civil Protection Directorate Sector for Radiological and Nuclear Safety	Croatia
Anna Balsamo	Health Ministry of Italy	Italy
Anne Jegouzo	Nuclear Safety Authority	France
Annette Röttger	European Radiation Dosimetry Group	Europe
Åsa Wiklund	Swedish Radiation Safety Authority	Sweden
Barbara Castrucci	Ministry of Ecological Transition	Italy
Bård Olsen	Norwegian Radiation and Nuclear Safety Authority	Norway
Beatrix Schönhacker-Alte	Republic of Austria Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology	Austria
Beatriz Robles Atienza	Nuclear Safety Council	Spain
Benjamin Klein	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection	Germany
Boris Dehandschutter	Federal Agency for Nuclear Control	Belgium
Carmela Carpentieri	Italian National Health Institute	Italy
Catarina Antunes	Portuguese Environment Agency	Portugal
Catherine Organo	Environmental Protection Agency	Ireland
Christian Di Carlo	Italian National Institute of Health	Italy
Claudia Engelhardt	Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection	Germany
Damijan Skrk	Slovenian Radiation Protection Administration	Slovenia
Daniela Maria Dogaru	National Commission for Nuclear Activities Control	Romania
David Fenton	Environmental Protection Agency	Ireland
Emilie van Deventer	World Health Organization	International
Fabio Barazza	Federal Office of Public Health	Switzerland
Francesco Bochicchio	Italian National Institute of Health	Italy
Francesco Salvi	Ispettorato Nazionale per la Sicurezza Nucleare e la Radioprotezione	Italy
Giuditta Garziano	Ministry of Ecological Transition	Italy
Gonzalo Valles Alberdi	Nuclear Safety Council	Spain
Guilherme Cardoso	Portuguese Environment Agency	Portugal

Haridasan Pappinisseri Puthanveedu	International Atomic Energy Agency	International
Heloisa Fonseca	Portuguese Environment Agency	Portugal
Ileana Radulescu	Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering	Romania
Isabel Marcos	Ministry of Transport, Mobility and Urban Agenda	Spain
Ivana Fojtíková	National Radiation Protection Institute	Czech Republic
Jelena Popic	Norwegian Radiation and Nuclear Safety Authority	Norway
João Oliveira Martins	Portuguese Environment Agency	Portugal
Karl Herlin	Swedish Radiation Safety Authority	Sweden
Kristína Zemková	Public Health Authority of the Slovak Republic	Slovak Republic
Luca Verdi	Environmental Protection Agency	Italy
Marcela Bercikova	State Office for Nuclear Safety	Czech Republic
Marco Brønner	Geological Survey of Norway	Norway
Margarida Malta	Portuguese Environment Agency	Portugal
Maria de Lurdes Dinis	University of Porto	Portugal
Maria José Trindade	Portuguese Environment Agency	Portugal
Maria Larsson	Norwegian Radiation and Nuclear Safety Authority	Norway
Maria Leier	Ministry of Environment	Estonia
Marielle Lecomte	Radiation Protection Department - Health Directorate	Luxembourg
Mario Caprio	Italian National Health Institute	Italy
Marta Gacia-Talavera	Nuclear Safety Council	Spain
Merixell Martell	Merience	Spain
Michael Murray	Environmental Protection Agency	Ireland
Niccolò Loret	National Research Council	Italy
Olga German	International Atomic Energy Agency	International
Olvido Guzman Lopez-Ocon	International Atomic Energy Agency	International
Päivi Kurttio	Radiation and Nuclear Safety Authority	Finland
Pierrick Jaunet	Nuclear Safety Authority	France
Pilar Linares Alemparte	Spanish National Research Council	Spain
Santiago Gonzalez Muñoz	Ministry of Health, Consumer Affairs and Social Welfare	Spain
Sara Antignani	Italian National Health Institute	Italy
Siiri Salupere	Republic of Estonia Environmental Board	Estonia
Sofie Apers	Belgian Nuclear Research Centre	Belgium
Sonia García-Ortega	Spanish National Research Council	Spain
Stefan Mundigl	European Commission	Europe
Sylvain Andresz	Nuclear Protection Evaluation Centre	France
Tanja Perko	Belgian Nuclear Research Centre	Belgium

Tomas Persson	Swedish Radiation Safety Authority	Sweden
Tracy Gooding	UK Health Security Agency	United Kingdom
Valeria Gruber	Austrian Agency for Health and Food Safety	Austria
Vladimir Udovicic	Institute of Physics Belgrade	Serbia
Wolfgang Ringer	Austrian Agency for Health and Food Safety	Austria
Ying Wang	Geological Survey of Norway	Norway
Zsolt Homoki	National Public Health Center	Hungary



Participants at HERCA 2nd NRAP workshop, 21-23 June 2022, Lisbon, Portugal (photo by APA).

