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Radon National Action Plan

Report of an International Workshop

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This report presents conclusions of an International workshop on radon national action plan. The workshop was organized in connection to radon requirements in EU Directive 2013/59/Euratom.

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Radon National Action Plan

Report of an International Workshop

Autorité de Sûreté Nucléaire
French Nuclear Safety
Authority
Montrouge, 2015

Statens strålevern
Norwegian Radiation
Protection Authority
Østerås, 2015

Preface

An international workshop about radon national action plan was co-organized by the French Nuclear Safety Authority (ASN) and the Norwegian Radiation Protection Authority (NRPA) as a result of successful collaboration on radon issues and a joint vision on the necessity to share views and experiences on radon control activities in European countries.

This report describes presentations and discussions held during the workshop from 30 September to 2 October 2014. The workshop was hosted by ASN in Montrouge, near Paris, France. Technical support was provided by a wide range of organisations via presentations and discussions, as described in the report.

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

This workshop report is edited by:

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Presentations given in workshop sessions can be found on:

http://www.french-nuclear-safety.fr/ASN/Professional-events/Radon-national-action-plan-workshop

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Contents

Preface ii

Acknowledgements iii

Executive summary v

Definitions vii

Abbreviations viii

1 Introduction 9

1.1 Radon National Action Plan Workshop 9
1.2 Participation 9
1.3 Report structure 9
1.4 Objectives of the workshop 10

2 Radon 11

2.1 Radon – a short background 11
2.2 National action plan to reduce radon exposure 11

3 Summary of presentations, discussions and conclusions from the workshop sessions 14

3.1 Introduction – NRPA, ASN, French Health Authority, WHO, IAEA, EC 14
3.2 Session 1 – Global strategy and national radon action plan 14
3.3 Session 2 – Actions to reduce radon exposure in dwellings 17
3.4 Session 3 – Actions to reduce radon exposure in workplaces and buildings with public access 18
3.5 Session 4 – Strategy for communication 19

4 Main conclusions of the workshop 21

5 References 23

Annex A – Program agenda 24

Annex B – Participants list 29

Executive summary

The ˝Radon National Action Plan Workshop˝ was organized jointly by the French Nuclear Safety Authority (ASN) and the Norwegian Radiation Protection Authority (NRPA) in ASN's premises (Montrouge, France), from 30 September to 2 October 2014.

The workshop was initiated in relation to the newly published EU Council Directive 2013/59/Euratom (BSS-Euratom), which states that the Member States of EU should, within a period of four years, define and adopt the national action plans for reducing radon exposure including all the relevant requirements in the Directive.

Major objectives of the workshop were:

- To facilitate the preparation or updating of the national action plans for reducing radon exposure by jointly addressing steps and activities in the implementation of the requirements in the BSS-Euratom (items listed in the annex XVIII of BSS-Euratom).
- To provide a forum for European countries to exchange information, experience and challenges related to the existing national strategies for reducing radon exposure.

The workshop was supported by the Heads of European Radiological protection Competent Authorities (HERCA), the World Health Organisation (WHO), the International Atomic Energy Agency (IAEA) and the European Commission (EC). Twenty European countries, represented by authorities in charge of Radiation Protection, Health, Labour and Housing and Landscaping were brought together during the workshop. Authorities from USA (EPA, CRCPD), Canada (CNSC), Russian Federation (FMBA) and representatives of the European Radon Association (ERA) participated also.

The workshop consisted of six sessions: an introduction, four separate working sessions and a closing session. About 90 participants, 33 of them giving presentations, were registered during the workshop. Each session was followed by a discussion to allow appropriate exchange of views, practices and experiences.

The main workshop conclusions are summarized as follows:

- Radon is a public health issue
- Long-term goal of national strategy for reduction of radon exposure is to reduce the lung cancer risk
- A national action plan for radon should aim at:
  - Reducing the individual lung cancer risk by reducing the high radon concentrations in existing dwellings (and other public access buildings/locations)
  - Reducing the overall lung cancer risk by reducing the average radon concentrations in the national housing stock (and other public access buildings/locations)
- National action plan should be based on knowledge of the radon situation in the country
- Both voluntarily and mandatory approaches for radon exposure reduction should be used in national action plan
- Legally binding regulations for radon levels in existing buildings such as schools, kindergartens, workplaces, buildings with public access and rental accommodations, should be considered
- Preventive measures in new buildings are cost effective
- People should be encouraged to utilise radon mitigation methods (information, motivation, incentives, confidence)

- Radon risk communication is an important aspect in national strategies for reducing lung cancer risk from radon
- Cooperation between different sectors at national, regional and local levels is an imperative for success in implementing the national strategies for radon reducing
- Radon national action plan should be evaluated and updated regularly

Definitions

Building professionals: this term describes all those involved in the design, construction, renovation and maintenance of buildings as well as those involved in the design and installation of radon prevention and mitigation systems.

Concentration: the activity of radon gas in terms of decays per time in a volume of air. The unit of radioactivity concentration is given in Becquerel per cubic metre (Bq/m^3).

Equilibrium factor (F-factor): radon is constantly decaying and giving rise to radon progeny. These are short-lived and decay until reaching a long-lived isotope of lead. The F-factor is used to describe the ratio between radon and its progeny. An F-factor of 1 means equal amounts of radon and its progeny. An F-factor of 0.4 is taken as representative for homes.

Homes or dwellings: these terms are interchangeable and refer to all detached and attached structures used for non-occupational human residency. The term “house” refers to a detached single-family dwelling.

Householders: this is a term of convenience used to collectively describe those living in a home or dwelling. It refers to occupants of the home, including owners of the property as well as tenants.

Mitigation or remediation: these terms are interchangeable and refer to steps taken in an existing building to reduce radon entry.

National radon programme: a series of measures, aimed at minimizing exposure of the population to radon, which are implemented by agencies designated by a national authority.

National radon survey: a survey carried out to determine the radon concentration distribution, which is representative of the radon exposure to the population within a country.

Prevention: measures installed during construction of new homes or dwellings aimed at preventing the entry of radon.

Radon-prone area: an area where a significant proportion of homes exceed the reference level.

Reference level: this level does not define a rigid boundary between safety and danger, but represents the annual mean radon concentration in a home above which it is strongly recommended or required to reduce the radon concentration.

Abbreviations

ASN	French Nuclear Safety Authority
BSS	Basic Safety Standard
CNSC	Canadian Nuclear Safety Commission
CRCPD	Conference of Radiation Control Program Directors
DCF	Dose Conversion Factor
EC	European Commission
EF	Equilibrium Factor
ERA	European Radon Association
FMBA	Burnasyan Federal Medical Biophysical Centre
HERCA	Heads of European Radiological protection Competent Authorities
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
NGO	Non-Governmental Organization
NRPA	Norwegian Radiation Protection Authority
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

1 Introduction

1.1 Radon National Action Plan Workshop

This report provides a summary of the ˝Radon National Action Plan Workshop˝ organized jointly by the French Nuclear Safety Authority (ASN) and the Norwegian Radiation Protection Authority (NRPA). The workshop was held in ASN's premises (Montrouge, France), from 30 September to 2 October 2014.

The workshop was supported by the Heads of European Radiological protection Competent Authorities (HERCA), the World Health Organisation (WHO), the International Atomic Energy Agency (IAEA) and the European Commission (EC).

In order to discuss all relevant issues related to radon national strategies and action plans, workshop sessions were organized as follows:

- Introduction,
- Session 1 – Global strategy and national radon action plans,
- Session 2 – Actions to reduce radon exposure in dwellings,
- Session 3 – Actions to reduce radon exposure in workplaces and buildings with public access,
- Session 4 – Strategy for communication,
- Conclusion,

In the *Introduction* session, representatives of international organisations (WHO, IAEA, EC) presented their views and main points in approaches for radon exposure reduction. Four *main* sessions, each dedicated to a pre-defined radon issue, were held in three workshop days. Intensive 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 complex radon issue. During the *closing* session, the main issues and key questions raised during the discussions were presented by rapporteurs and the chair drew the main conclusions of the workshop.

1.2 Participation

Authorities in charge of Radiation Protection, Health, Labour, Housing and Landscaping, from 20 European countries, were brought together during this workshop to share their views and experiences concerning national strategies for reducing radon exposure of the population and associated lung cancer risk. Authorities from USA (Environmental protection Agency (EPA)), Conference of Radiation Control Program Directors (CRCPD)), Canada (Canadian Nuclear Safety Commission (CNSC)), Russian Federation (Burnasyan Federal Medical Biophysical Centre (FMBA)) and representatives of the European Radon Association (ERA) participated also.

1.3 Report structure

This report contains information on the workshop structure and objectives, a short background on the radon issue and on the concept of national action plan, a summary of the discussions and key-points in each of the workshop sessions and the main overall conclusions of the workshop. The programme and the list of participants are included in Annex A and B at the end of the report.

The report has been prepared for distribution to participants, but it is also intended as a resource for those interested in the content of the workshop and for those who deal with radon policies within national strategies.

1.4 Objectives of the workshop

Radon has been a well-known health risk for many years. Epidemiological findings have statistically confirmed a significant relationship between radon exposure and lung cancer risk in the general population. These findings have led to increased national and international attention on radon and its health effects.

A way forward in managing radon risk is through the development and implementation of national action plans. This concept has been raised as an important issue in the recent EU Basic Safety Standards (2014), as well as being earlier recommended in the WHO Handbook on indoor radon (2009) and the International Basic Safety Standards (2011).

According to EU Council Directive 2013/59/Euratom of 5 December 2013, the Member States of the EU should, within a period of four years for transposition of the Directive, define their national action plans for reducing radon exposures:

˝Member States shall establish a national action plan addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water...˝

Furthermore, the Directive specifies a maximum value for the national reference levels, sets requirements for occupational exposure including dose limit, addresses exposure of members of public in particular with regard to new buildings, etc.

With respect to this, the main objectives of the workshop were:

- *To facilitate the preparation or updating of the national action plans for reducing radon exposure by jointly addressing steps and activities in the implementation of the requirements in the BSS-Euratom (items listed in the annex XVIII of BSS-Euratom).*
- *To provide a forum for European countries to exchange information, experience and challenges related to the existing national strategies for reducing radon exposure.*

2 Radon

2.1 Radon – a short background

Radon (Rn) is a colourless, odourless and tasteless noble gas. It is a naturally occurring radionuclide produced by the radioactive decay of uranium (U) and thorium (Th), which are present in all soils and rocks, albeit usually in small quantities. There are a number of isotopes of radon, but the most important in terms of health effects are ^{222}Rn (related to ^{238}U) and ^{220}Rn (related to ^{232}Th). Radon-220, historically known as thoron (because of its parent radionuclide ^{232}Th), was not specifically addressed during this workshop.

Radon (^{222}Rn) has a 3.82-day half-life and it can therefore be transported in the ground with soil-air movement before it decays. When it escapes from soil to the outdoor air, it is quickly diluted to low concentrations. According to UNSCEAR (2006), the observed worldwide outdoor concentrations of radon are low, with an arithmetic mean value of 10 Bq/m^3. However, soil radon gas is also easily transported into buildings via pressure driven flow of soil gas through cracks in the foundations of buildings. Radon gas entering buildings in this manner can build up in enclosed spaces. Therefore, indoor radon concentrations can reach much higher values compared to outdoors *e.g.*, in underground mines and in homes (up to thousands of Bq/m^3).

Radon is responsible for approximately 40 % of the global annual average individual effective dose from all sources of radiation (UNSCEAR, 2008). Individual doses could be significantly elevated due to high indoor radon concentrations, and there are regional variations depending on local geology, building construction practices and various environmental factors. These can make the radon problem more important in some areas of the world compared to others. Worldwide, the important contribution of radon to the overall exposure of humans needs special attention.

Scientific evidence of the health risks from radon as a contributing causal factor for lung cancer in the general population has been confirmed in several international studies (Darby *et al*., 2005; Krewski *et al*., 2005; Lubin *et al*., 2004). Current estimates of the proportion of lung cancers attributable to radon range from 3 to 14 %, depending on the average indoor radon concentration in the country and the calculation methods. The analyses indicate that the lung cancer risk increases proportionally with radon exposure (WHO, 2009).

2.2 National action plan to reduce radon exposure

Based on scientific evidence, the International Commission on Radiological Protection (ICRP), IAEA and WHO updated recommendations on how to assess and manage risks from long-term radon exposure. The necessity of actions to reduce radon exposures has been highlighted during the last decade.

The new European Basic Safety Standards - Council Directive 2013/59/Euratom of 5 December 2013, laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation, were published in January 2014. The new Directive covers now all relevant radiation sources including those of natural origin. A major novelty is that the BSS now explicitly address the long-term health risks from radon exposure. While the Directive contains a number of legally binding requirements for the protection of the public and the protection of workers from exposure to radon, it leaves flexibility for their implementation in different countries. EU Member States shall bring into force the laws, regulations and administrative provisions, necessary to comply with this Directive by 6 February 2018.

The Directive requires the establishment of a national radon action plan addressing long-term risks from radon in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water (Article 103).

Member States shall establish national reference levels for indoor radon concentrations. The reference levels for the annual average indoor activity concentration in air shall not be higher than 300 Bq/m^3.

Further to this, Member States shall identify areas where the radon concentration in a significant number of buildings is expected to exceed the national reference level (˝radon prone areas˝).

Appropriate measures shall be established to prevent radon ingress into new buildings (for instance, through specific requirements in national building codes).

With regard to public exposures (Article 74), Member States shall promote action to identify existing dwellings with radon concentrations exceeding the reference level and encourage radon reducing measures in these dwellings.

Member States shall also ensure that local and national information is made available on indoor radon exposure and the associated health risks, on the importance of performing radon measurements and on the technical mitigation methods available for reducing existing radon concentrations.

With regard to occupational exposures (Articles 54, 25 (2), 35 (2)), Member States shall establish national reference levels for indoor radon concentrations in workplaces. The reference level for the annual average indoor activity concentration in air shall not be higher than 300 Bq/m^3, unless it is warranted by national prevailing circumstances. Radon measurements shall be carried out in types of workplaces specified in the national radon action plan. In cases where the radon concentration continues to exceed the reference levels for workplaces, despite all mitigation measures, the competent authority shall be notified. If the exposure of workers in these identified workplaces is liable to exceed 6 mSv/y (or an equivalent time-integrated radon concentration) the practice should be treated as a planned exposure situation and the relevant occupational exposure arrangements of the Directive shall apply.

A list of items to be considered in preparing the national action plan to address long term risks from radon exposures is given in Annex XVIII of the BSS-Euratom:

(1) Strategy for conducting surveys of indoor radon concentrations or soil gas concentrations for the purpose of estimating the distribution of indoor radon concentrations, for the management of measurement data and for the establishment of other relevant parameters (such as soil and rock types, permeability and ^{226}Ra content of rock or soil).

(2) Approach, data and criteria used for the delineation of areas or for the definition of other parameters that can be used as specific indicators of situations with potentially high exposure to radon.

(3) Identification of types of workplaces and buildings with public access, such as schools, underground workplaces, and those in certain areas, where measurements are required, on the basis of a risk assessment, considering for instance occupancy hours.

(4) The basis for the establishment of reference levels for dwellings and workplaces. If applicable, the basis for the establishment of different reference levels for different uses of buildings (dwellings, buildings with public access, workplaces) as well as for existing and for new buildings.

(5) Assignment of responsibilities (governmental and non-governmental), coordination mechanisms and available resources for implementation of the action plan.

(6) Strategy for reducing radon exposure in dwellings and for giving priority to addressing the situations identified under point 2.

(7) Strategies for facilitating post construction remedial action.

(8) Strategy, including methods and tools, for preventing radon ingress in new buildings, including identification of building materials with significant radon exhalation.

(9) Schedules for reviews of the action plan.

(10) Strategy for communication to increase public awareness and inform local decision makers, employers and employees of the risks of radon, including in relation to smoking.

(11) Guidance on methods and tools for measurements and remedial measures. Criteria for the accreditation of measurement and remediation services shall also be considered.

(12) Where appropriate, provision of financial support for radon surveys and for remedial measures, in particular for private dwellings with very high radon concentrations.

(13) Long term goals in terms of reducing lung cancer risk attributable to radon exposure (for smokers and non-smokers).

(14) Where appropriate, consideration of other related issues and corresponding programmes such as programmes on energy saving and indoor air quality.

3 Summary of presentations, discussions and conclusions from the workshop sessions

The information provided here does not necessarily include all the information presented. Readers are encouraged to contact authors for more information.

3.1 Introduction – NRPA, ASN, French Health Authority, WHO, IAEA, EC

The Heads of NRPA, ASN and the French Health Authority opened the workshop.

The French Health Authority presented initially the health component on radon exposure in France and the main lines of the French strategy against radon exposure. It was particularly highlighted the fact that radon represented one of the major health risks associated with indoor air quality, but still it was an underestimated issue in the population. That's why communication strategies and regulation implementation need to be established in order to target both general and locally exposed populations.

Presentations from the international organizations WHO, IAEA, EC focused generally on the main items of the global radon strategy and on the importance of national action plans for reducing radon exposure.

World Health Organisation presented the WHO Handbook on Indoor Radon (2009) and highlighted the need for national radon programs comprising several routs of action to reduce radon exposure. Activities and items to be included in national radon programs were explained. The importance of multi-level collaboration, the role of politicians and authorities, financial considerations, mandatory versus voluntary approaches and establishing a national reference level were also discussed.

The representative from the IAEA presented the radon requirements in the International BSS and the difficulties in the implementation of national action plans. The basic approach to developing a national radon strategy, comprising of information on radon levels in the country, radon measurements and radon national action plan as key issues, was considered. The most common action inhibitors were discussed.

The representative from the European Commission reported on the legal basis, history, background, legal status and objectives of Euratom radiation protection legislation in general and of the new Euratom BSS Directive in particular. The EC representative summarised the radon requirements in the new Euratom BSS Directive (see chapter 2.2) and emphasized the fact that Member States of the European Union will have to transpose the Directive into national legislation by 6 February 2018.

3.2 Session 1 – Global strategy and national radon action plan

Ten speakers (from European countries, Canada and US) participated in Session 1 dedicated to *Global strategy and national radon action plans*.

Representatives from all countries emphasized the importance of national strategies for radon reduction, although somewhat different approaches for radon reduction were presented. The long-term objective of national action plans was reducing the lung cancer risk caused by exposure to radon by reducing indoor radon concentrations. The main routes of action, lessons learned and some ideas for consideration were presented.

Based on known radon levels and primarily geological factors, there are some countries with relatively high average indoor radon concentrations (*e.g.*, Czech Republic, Finland, Sweden, Norway, Ireland) and/or elevated radon levels in radon prone areas (*e.g.*, France, Switzerland,

Belgium, Czech Republic). Estimations of the lung cancer incidence rates attributed to radon in different countries (*e.g*., US, Ireland, Norway) have confirmed radon as a public health issue.

Radon is a multidisciplinary issue that needs expertise from several sectors to be solved in a comprehensive way. Experiences with assignment of responsibility for radon control issues at national and local levels, advantages and disadvantages were presented. It was judged as efficient having one authority which synchronizes the radon reduction activities and follows-up the radon strategy.

The importance of intensive multi-level collaboration, as well as importance of jurisdictional regulatory and risk management frameworks (including political support and different stakeholders), was highlighted.

Certain differences regarding voluntarily and mandatory approach were discussed.

The thematic working areas, defined and adopted in national action plans of participating countries, were as follows:

- Radon measurements/mapping to increase the knowledge and understanding of radon in the country, a radon database, mapping, definition of radon prone areas
- Prevention in new buildings; radon in building codes
- Radon and land-use planning
- Radon in workplaces and buildings with public access (incl. schools and kindergartens)
- Incentives in place to control radon exposure - efficient strategy for remediation, supporting the individuals
- Use of property transactions (the housing market) to drive radon testing
- Building public confidence in radon services offered by private entrepreneurs
- Developing guidelines and/or standards for mitigation/prevention
- Work on education and training of professionals

Some of the challenges regarding the implementation of a national action plan and radon reduction activities were listed as:

- low effectiveness of voluntary measures *i.e*., radon recommendations, complexity of the process to include radon requirements/legally binding values (resistance in some state sectors),
- low public awareness and general public reluctance to measure and remediate private homes, question of efficiency of mitigation measures and how to obtain and install the best option,
- general low confidence in mitigation methods, question of energy saving measures and creation of new radon problems,
- quality control of radon measurements, underestimation of radon risk and difficult risk communication,
- addressing smokers/former smokers/never smokers in risk campaigns,
- dose calculation and conversion Bq/m^3 to mSv regarding occupational exposure,
- re-evaluation of radon risk after adoption of new reference levels, etc.

It was concluded that national radon programmes presented during the workshop have been successful, but that there still is a need to review certain aspects, especially to increase awareness and to speed up the pace of measurement and remediation measures.

Key-points of the session 1

- Scientific evidence has proved that radon is a health risk and public health issue. Significant relationship between radon exposure and lung cancer risk has been confirmed. There is consensus on the need for national radon strategy and a national radon action plan.
- Radon is a multi-disciplinary issue that needs to be addressed in wide collaboration of different sectors and authorities at national, regional and local levels. Engaging politicians, stakeholders, NGOs to launch the campaign and assert the long range goals is necessary.
- A national radon action plan is required by the BSS-Euratom, strongly supported by the International BSS and the WHO Handbook on radon. The list of radon items is available in BSS-Euratom (Annex XVIII) as support in developing the national action plans.
- National radon action plans should be based on radon knowledge (indoor concentration surveys, awareness surveys, economic analysis) and cooperation (at national, regional and local levels).
- The transparency and efficiency of actions for the reduction of radon concentrations and lung cancer risk should be assessed at regular intervals.
- Important issues in national radon action plans considered during the workshop:
    - All sources of radon ingress should be considered (soil, building materials, water).
    - All types of buildings should be addressed (existing and new private dwellings, schools, kindergartens, workplaces, other buildings with public access).
    - The assignment of responsibility for radon issues, as well as identification of possible issues that are outside of any specific responsibility, should be done.
    - Both, voluntary and mandatory approaches (reference levels and regulations) should be considered within the action plan with a reasonable balance.
    - Cost-efficiency analysis of radon actions is important (*e.g.*, for risk management and decision making).
    - Quality control of radon measurements, mitigation and prevention actions should be in place. Approved standard guidelines and protocols for these should be available.
    - Radon prevention is of the importance as well radon reduction.
    - It could be useful to include radon item in indoor air quality item checklist for new buildings, parallel with other parameters.
    - Coordination of radon indoor air quality and energy efficient construction activities is needed.
    - It is important to build up confidence in different radon services (measurement, prevention, remediation).
    - Risk communication and raising the public awareness are very important. The differences in risk for smokers compared to never-smokers should be particularly addressed.
    - It will be necessary to invest in training and education of professionals (building professionals, architects, radiation protection professionals, mitigation professionals).
    - Strong incentives (*e.g.*, financial support) may be helpful to stimulate the use of radon mitigation measures, especially in radon prone areas.

3.3 Session 2 – Actions to reduce radon exposure in dwellings

Speakers from 6 European countries participated in session 2 presenting their views and experiences on the main topic of the session: *Actions to reduce radon exposure in dwellings*.

Radon concentrations in European dwellings are log-normally distributed with the average annual indoor concentration up to 120 Bq/m^3 and generally about 5 % of housing stock with radon concentrations over 400 Bq/m^3. Somewhat different national reference levels (100, 200 and 400 Bq/m^3) and intervention criteria (200, 400 Bq/m^3) were presented and it was concluded that an update in relation to the requirement of the BSS-Euratom (reference level of 300 Bq/m^3) is needed in some countries.

Radon reduction in certain radon prone areas can pose a special challenge. The national strategies should include this as a separate topic.

Management, assessment and risk communication on the example of one individual case with extremely high radon exposure highlighted the complexity of radon control in such situations. The origin of the problem in the presented case was the legacy of past mining, but these kinds of extremely high radon areas can be found in nature and complexity of the management is the same. The importance of full transparency with the persons involved was emphasized.

An overall agreement about installation of preventive measures when constructing new homes was reached. The efficiency of these has been confirmed in several countries where specific actions and targeted radon measurements in new homes have been carried out. The radon issue should be included in standard requirements in building designs and constructions used to ensure acceptable indoor air quality, thermal comfort and to avoid humidity problems.

The development of national radon database is of importance since it contributes to spreading the information and knowledge among the population, but also helps in individual cases when/if data on radon levels in certain homes during the past are needed. Furthermore, radon concentration data might be used in combination with geological data to give combined maps, useful in identification of radon prone areas and for land use planning.

Some of the countries presented their experiences on how to include radon in house buying/selling processes, as well as the advantages and disadvantages of that.

As mentioned before, radon is a public health issue and radon prevention should be done as a comprehensive collaboration of many governmental and local bodies. One significant way of radon prevention is through systematic public health work in municipalities.

The question of the impact of energy saving measures in buildings on indoor radon concentrations was raised during this session. Built of energy saving buildings, as well energy renovation of buildings, is a great challenge for the future since retrofitting measures could affect indoor radon in a negative way. Geology, technical installations and human factors may be of significant importance for radon increase in houses with energy-saving measures and thus, these issues need to be properly addressed.

Identification and remediation of existing dwellings are some of the biggest challenges related to radon exposure reduction. How to best inform and encourage people to make radon measurements and perform mitigation is still related to a range of problems. Choice of remediation strategy should be based on a combination of different factors such as radon indoor level, implementation technique, possibilities for maintenance, costs and energy need for thermal comfort.

Key-points of session 2

- It is important to establish national radon reference levels for dwellings.
- Both regulatory and mandatory approaches, *i.e.*, encouragement and regulation, should be used in national action plans concerning activities for reduction of radon in dwellings. Individual dwellings and collective buildings should be taken into the consideration.
- It is necessary to have control of compliance of regulation (strategy and instrument, inspection and breaches, periodicity of measurements) and quality control of radon measurements (reliability, comparability).
- The remediation of old buildings is related to many problems. There is a need for general standards and the development of guidelines. All remediation measures should be based on cost-effectiveness research.
- It is necessary to establish the reference level for new buildings. Positive experiences with legally binding values for new-built and their positive influence on other domains of radon exposure were presented.
- Considering radon when developing construction regulations/building codes is necessary.
- Importance of prevention in new-built (under construction) was highlighted. Efficiency of preventive measures has been confirmed. However, assignment of some responsibilities (like for control measurements of radon in new build) is still not easy.
- Energy saving measures and radon/indoor air quality are challenges for the future that need to be tackled.
- Targeted surveys should be part of national action plans to identify high radon areas.
- Management of high level radon exposure is a complex process and includes assignment of responsibilities, cooperation with local authorities, coordination, risk assessment, transparency in all processes, sharing the information with the public and individuals. A case by case strategy may be needed in some high radon areas.
- Positive experiences with strategy for radon reduction and risk communication through providing the radon information in house selling/buying procedures and through adoption and enforcement of legally binding values for radon in rental accommodations were presented.
- Training and enhancement of radon knowledge in building professionals is necessary and should be done through different sources and multi-sectors collaboration.

3.4 Session 3 – Actions to reduce radon exposure in workplaces and buildings with public access

Four presentations were given in session 3: *Actions to reduce radon exposure in workplaces and buildings with public access.*

The responsibility for control of radon exposure at workplaces is usually delegated to a national Working Environment Authority.

The new BSS-Euratom require the establishment of a national reference level for indoor radon concentrations in workplaces which shall not be higher than 300 Bq/m^3. Workplaces where higher concentrations of radon are measured need to be notified to the competent authority and further

monitored. Such workplaces include mines, water purification plants, underground facilities like archives and stores, spas, jails, tunnels, underground buildings with poor ventilation, etc.

Calculation of occupational doses based on measured indoor radon concentrations includes use of coefficients, *i.e.*, dose conversion factor (DCF), equilibrium factor (Fi) and is, thus, related to large uncertainties. Graded approaches, that consider several exposure situations at different workplaces with several levels of applicable reference values (200 – 3000 Bq/m^3), are in use in some countries.

In order to comply with the new BSS-Euratom, radon reference levels in working places need to be redefined in many European countries. For some of them this will pose a great challenge to regulatory systems.

Key-points of session 3

- Different concepts of reference level in ICRP Publication 103 and in EU Directive 2013/59/Euratom leads to difficulty when adopting radon control in workplaces. The question of whether radon protection at work is based on public health considerations or on radiation protection for workers is not simple to answer.
- List of workplaces where radon measurements are required should be regularly revised and updated.
- The communication of new reference level of 300 Bq/m^3 will be a challenge for some countries.
- Strategies and instruments to control the compliance with regulations should be improved.
- Collective occupational radon exposure is lower than collective exposure in dwellings, but still mitigation may be cost-effective.
- Instruments for the control of mitigation should be improved.
- Regulating radon in public buildings, *i.e.*, schools and kindergartens should be considered where possible. There are experiences where enforcement of regulation in this radon domain has had a positive influence on people's willingness to measure and mitigate radon in their homes.
- In general, awareness of employers about radon risk is relatively low.
- Good risk communication concerning new requirements is crucial and will be difficult.
- An appropriate time period should be allowed to achieve compliance with new requirements. It is useful to have pragmatic approaches with simple and not expensive solutions on radon control at workplaces.

3.5 Session 4 – Strategy for communication

Session 4: *Strategy for communication* was the last session and 5 presentations were held in this session.

In general, the awareness on radon risk varies from country to country; though efforts to improve it are necessary in many countries. The communication strategy has to be planned in a way to include several important aspects such as objectives, target groups, communication techniques, communication channels, format and communication style, advantages and possible obstacles, cooperation, evaluation of the results, etc.

The information on radon and related health risk should be given to different groups of people including homeowners, landlords, employers, solicitors, estate agents, building professionals, architects, radon remediators, officers in local and national government and family doctors. Some countries had good experiences with arrangements like, for instance, national radon month/week. The communication channels, such as letters through the post, newsletters for professionals, adverts in newspapers, speaking at meetings of professional groups, participation in local radios and "on the sofa" of national family television programmes, web presence, Tweets and YouTube videos, reach different groups of people. Thus, it is of great importance to consider it when planning the actions on enhancement of the radon awareness. Radon messages sent should be effective, consistent, clear, simple and accurate.

Perceived versus real risk from radon is a big challenge for all countries. However, experiences with positive effects of legislation in certain radon domains on the radon awareness in the general public and spin-off effect in other radon domains have been observed.

Key-points of session 4

- There is a general consensus on the necessity to increase the awareness of radon and its related health risk.
- Persuading different stakeholder groups (public, landlords, employers, professionals, etc.) to measure radon and remediate when necessary is complex and difficult and needs an efficient strategy.
- Messages about radon should be adapted to each targeted group – not all need to know everything about radon.
- Important to have various communication channels and professionals that will conduct targeted actions on enhancement of the radon risk awareness.
- Message to general population – simple but efficient such as "Protect your family".
- Should radon be included in anti-smoking campaign? Not likely that smokers will care about radon. Radon is related to lung cancer risk for smokers, former smokers and never smokers. Radon levels should be reduced and message about radon issue should be sent to general public, smokers or not.
- Radon risk in exceptionally high radon areas should be especially considered; proper risk communication in these areas is of high importance.
- Positive experiences were shared on having radon in real-estate transactions.
- The importance of evaluation of communication strategies and assessing what they achieve was highlighted. Both good and bad achievements should be shared so that things can be improved. The idea of collaboration on this subject on international level was discussed.

4 Main conclusions of the workshop

Based on given presentations, intensive discussions in each of the sessions and reports from each of the sessions, the main conclusions of the workshop are summarized as follows:

- **Radon is a public health issue**
- **The long-term goal of a national strategy for reduction of radon exposure is to reduce the lung cancer risk**
- **A national action plan for radon should aim at reducing:**
  - **the individual lung cancer risk by reducing the high radon concentrations**
  - **the overall lung cancer risk by reducing the average radon concentrations**
- **Cooperation is an imperative for success**
  - Authorities that work with different radon issues at national, regional and local levels must cooperate in order to obtain best possible results. Cooperation with NGOs and involvement of politicians and target stakeholders is also of importance. It has been shown that assignment of responsibility where one authority/organisation has the main role of the implementation and coordination of the action plan gives successful results. In order to ensure the continuation of radon activities in different fields, it is important to identify radon issues that could potentially be neglected.
- **Action plans should be based on knowledge**
  - Surveys of indoor radon concentrations in different types of building
  - Surveys of radon awareness
- **Both voluntarily and mandatory approach for radon exposure reduction should be used in national action plan, within reasonably chosen boundaries**
  - National reference levels for radon should be established in national action plans
  - In some domains of radon exposure, such as in in new-built, rental accommodations, schools and kindergartens, specific workplaces, buildings with public access, enforcement of legally binding regulations should be considered. It was confirmed that regulations often affect the public's attitude towards radon and risk awareness in a positive way.

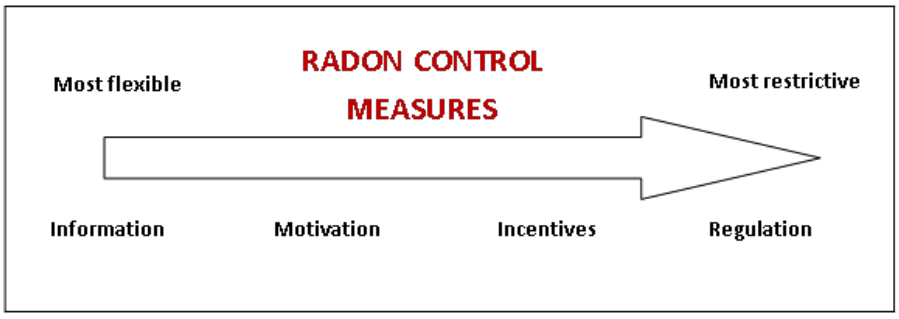


Fig. 1. Radon control approaches (ERA, Radon workshop, 2014).

- **Preventive measures in new buildings are necessary**
  - Cost-efficiency analyses have shown the necessity of radon prevention measures in new buildings. Radon should be considered as an air quality factor.
  - Radon should be particularly addressed in cases of all types of energy saving buildings.
- **Radon mitigation – people should be encouraged**
  - Guidelines and/or standard protocols for mitigation in existing buildings should be published.
  - Education and training programs for professionals should be available.
  - High radon areas – incentives to support the mitigation should be provided.
- **Radon risk communication – an important point in any national strategy for radon reduction**
  - People should be encouraged to measure radon and mitigate if necessary.
  - Message should be effective, consistent, clear, simple and accurate.
  - Pre-selected target groups should receive customized information.
  - Appropriate communication channels should be used.
  - Cooperation of authorities on different levels is needed in order to send coordinated and consistent message.
- **Radon national action plan should be evaluated and updated regularly**

5 References

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Annex A – Program agenda

Radon National Action Plan Workshop

From 30 September to 2 October 2014

At the **Nuclear Safety Authority (ASN)**

In meeting room: 'Hall Advisory Committees' GP 1-2-3-4 (Ground floor)

15 rue Louis Lejeune – 92 Montrouge (France)

Workshop program

Tuesday 30th September 2014

13:00	Registration
	Introduction
	Chairperson: Pierre-Franck Chevet (ASN)/Co-Chairperson: Per Strand (NRPA)
13:30	**Official welcome** - *Pierre-Franck Chevet* (ASN)/ *Per Strand* (NRPA)
13:45	French Health General Director (*Professor Benoit Vallet*)
14:00	*WHO, Emilie Van Deventer*
	Radon, a public health priority
	The concept of national programs in the radon Handbook
14:15	*IAEA, Tony Colgan*
	Radon requirements in the IAEA BSS. Difficulties encountered in the implementation of radon action plans
14:30	*EU Commission, Stefan Mundigl*
	Radon requirements in the EU BSS. Policy committee in support of the implementation of the 2013/59 Directive on the subject of radon
14:45-15:00	Questions to speakers

Session 1: Global strategy and national radon action plan

Chairperson: S. Magnusson (HERCA)/Co-Chairperson: Tony Colgan (IAEA) and rapporteurs NRPA/ASN

15:00	**How the U.S. developed a national radon action plan: lessons learned and ideas to consider,**
	Bill Long from US Environmental Protection Agency and Ruth McBurney from the Conference of Radiation Control Program Directors, USA
15:30	**Canadian radon strategy and action plan,**
	Patsy A. Thompson from Canadian Nuclear Safety Commission, Directorate of Environmental and Radiation protection and Assessment, Canada
15:50	**Development of the Irish national radon control strategy,**
	David Pollard, David Fenton and Stephanie Long from the Radiological Protection Institute of Ireland, Ireland
16:10-16:25	Questions to speakers
16:25-16:40	*Coffee*
16:40	**The Belgian radon action plan,**
	Boris Dehandschutter from the Federal Agency for Nuclear Control, Belgium
17:00	**The Swiss national radon action plan 2012/2020,**
	Christophe Murith from FOPH, Switzerland
17:20	**Existing strategy and challenges for a national action plan for radon in Sweden,**
	Kirlna Skeppström from Swedish Radiation Safety Authority, Sweden
17:40	**National radon action plan of Czech Republic, 15 years of experience with radon program,**
	Karla Petrová, Jana Davidková, Eva Pravdová, State Office for Nuclear Safety, Czech Republic
18:00	**Radon regulatory framework in the Russian Federation: state of affairs and new challenges,**
	Sergey Kiselev, Burnasyan Federal Medical Biophysical Center, Russian Federation
18:20-18:30	Questions to speakers
18:30	End of day (session 1 will continue on the 2nd day)

Cocktail offered by ASN

Wednesday 1st October 2014

Session 1 (suite): Global strategy and national radon action plan

Chairperson: S. Magnusson (HERCA)/Co-Chairperson: Tony Colgan (IAEA) and rapporteurs NRPA/ASN

09:00	**National strategy for radon in Norway,**
	Jelena Mrdakovic Popic from the Norwegian Radiation Protection Authority (NRPA), Norway
09:20	**Radon national action plan in France,**
	Jean-Luc Godet from the French Nuclear Safety Authority (ASN), France
09:40-09:55	Questions to speakers
09:55-10:10	*Coffee*
10:10-11:10	**Discussion about global strategy**
	Chairperson: S. Magnusson (HERCA) and Co-Chairperson: Tony Colgan (IAEA)

Session 2: Actions to reduce radon exposure in dwellings

Chairperson: Emilie Van Deventer (WHO)/C-Chairperson: Patsy Thompson (CNSC) and rapporteurs NRPA/ASN

11:10	**High radon levels in UK homes: progress and plans,**
	Neil McColl from CRCE, Public Health England, UK
11:30	**High radon levels in French homes (Bessines)**
	Jeremie Vallet (Environment ministry) and Alain Rannou (IRSN), France
12:00	**Radon exposure in Finland,**
	Päivi Kurttio from Radiation and Nuclear Safety Authority (STUK), Finland
12:20	**Radon prevention through systematic public health work in a municipality,**
	Finn Martinsen from Norwegian Directorate of Health, Norway
12:40-12:55	*Questions to speakers*
12:55-13:45	Lunch
13:45	**Radon protection in occupied buildings in Swiss building standards,**
	Claude-Alain Roulet from the School of engineering and architecture of Fribourg
	Radon and energy saving measures in new and existing buildings in Switzerland,
	Joëlle Goyette from the School of engineering and architecture of Fribourg

14:15	**The cost of ventilation as a solution for reducing indoor radon in terms of energy efficiency loss,**
	Borja Frutos and Manuel Olaya from Eduardo Torroja Institute of buildings science, Spain
	The future Spanish building code on the radon protection area,
	Linares-Alemparte Pilar Architect, Spain
14:45-15:00	Questions to speakers
15:00-16:00	**Discussion**
	Chairperson: Emilie Van Deventer (WHO)/Co-Chairperson: Patsy Thompson (CNSC)
16:00-16:15	*Coffee*

Session 3: Action to reduce radon exposure in workplaces and in buildings with public access

Chairperson: Bill Long (US EPA)/Co-Chairperson: Margot Timarche (ASN) and rapporteurs NRPA/ASN

16:15	**Action to reduce radon exposure at workplaces and in buildings with public access,**
	Janez Marinko from the Swedish Work Environment Authority, Sweden
16:35	**The regulation of occupational radon exposure in Spain,**
	Marta Garcia-Talavera from Consejo de Seguridad Nuclear (CSN), Spain
16:55	**Radon protection in Swiss workplaces,**
	Lisa Pedrazzi from Occupational Safety and Health Department, Switzerland
17:15	**French regulatory framework for radon exposure in workplaces and buildings with public access,**
	Eric Dechaux from French Nuclear Safety Authorty (ASN), France
17:25-18:15	**Discussion**
	Chairperson: Bill Long (US EPA)/Co-Chairperson: Margot Tirmarche (ASN)
18:15	End of the day

Thursday 2nd October 2014

Session 4: Strategy for communication

Chairperson: Augustin Janssens (Expert)/Co-Chairperson: Solveig Dysvik (NRPA) and rapporteurs ASN/NRPA

09:30	**Radon Program of the Czech Republic – information strategy**
	Karla Petrová, Jana Davidková, Eva Pravdová from State Office for Nuclear Safety, Czech Republic
09:50	**Some UK experience of communicating about radon: who needs to know what and how can we reach them?**
	Neil Mc Coll from Public Health England, UK
10:10-10:30	Questions to speakers
10:30-10:45	*Coffee*
10:45	**Strategy for communication,**
	Anne Marit Skjold from Norwegian Radiation Protection Authority, Norway
11:05	**Approach and evaluation of the radon communication plan in Belgium,**
	Boris Dehandschutter from the Federal Agency for Nuclear Control, Belgium
11:25	**Some perspectives on the design of strategies for effective communication of radon risk to the public,**
	James Mc Laughlin (President of ERA), School of Physics, University College Dablin, Ireland and Jose-Luis Gutiererrez-Villanueva (Secretary of ERA), University of Cantambria, Spain
11:50-12:10	Questions to speakers
12:10-13:15	**Discussion**
	Chairperson: Augustin Janssens (Expert)/Co-Chairperson: Solveig Dysvik (NRPA)
13:15-14:15	*Lunch*

Conclusion

Chairperson: Per Strand (NRPA)/Co-Chairperson: Margot Tirmarche (ASN)

14:15	Reports from the sessions by rapporteurs (10 min for each session)
14:55	Question to rapporteurs/comments on the reports
15:05	**EU Commission point of view on the main issues raised during the workshop**
	Stefan Mundigl from EU Commission
15:20	**Main findings of the workshop,**
	Per strand from the Norwegian Radiation Protection Authority
15:30	**End of the workshop**

Annex B – Participants list

Radon National Action Plan Workshop

Montrouge, 30th September 2014 to 2nd October 2014

BENGTSSON Emil	:	Radiation Safety Authority, Sweden
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Statens strålevern
Norwegian Radiation Protection Authority

2015

StrålevernRapport 2015:1
Strategisk plan 2015–2017

StrålevernRapport 2015:2
Årsrapport 2014

StrålevernRapport 2015:3
Radioactivity in the Marine Environment 2011

StrålevernRapport 2015:4
Effekt av KVIST-arbeidet

StrålevernRapport 2015:5
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