Executive Summary

The Research Project MetroRADON (Metrology for Radon Monitoring) started in June 2017 and is funded within the European Metrology Programme for Innovation and Research (EMPIR). The 3-year project was extended for 6 months because of Covid-19 and comes to its end in November 2020. Within the project, 17 European national metrology institutes and research institutes as well as 9 official collaborating institutions aimed to provide metrology for radon monitoring.

The purpose of the project was to develop reliable techniques and methodologies to enable SI traceable radon activity concentration measurements and calibrations at low radon concentrations. The need for this project has been largely motivated by the requirements of the implementation of the European Council Directive 2013/59/EURATOM (EU-BSS), one aim of which is to reduce the risk of lung cancer for European citizens due to high radon concentrations in indoor air.

As an outcome of the project the metrological infrastructure for calibration of radon measurement instruments for low radon activity concentrations exist and a network of calibration institutes was established. The impact of Thoron on radon measurements were evaluated with one patent submitted. An involvement and networking of the industry was reached and guidelines were published. The quality standards of radon measurements were evaluated by comparison measurements. The definition of radon priority areas and different mapping methods in Europe were assessed and possible new radon mapping method for Europe was developed (Geogenic Radon Hazard Index).

The work and results of MetroRADON was presented more than 75 times at international conferences and workshops and 14 articles in peer reviewed papers were published already, more will follow. In addition, the MetroRADON results are summarized in guidelines, reports and deliverables. To involve the industry an Industry Interest Group was established and network possibilities were given. All the stakeholders were invited to the MetroRADON workshops and training courses (see details in this newsletter). Five newsletters reporting the work done and progress within the project were sent to the 250 stakeholders from industry, national authorities, research institutes and associations.

In this 6th final newsletter, the main work and results of all five workpackages of the MetroRADON project are summarised. In addition a reference list of the peer reviewed paper is given in the end.

All the MetroRADON dissemination material is available on the MetroRADON website.

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MetroRADON Partnership

BEV-PTP: Physikalisch-Technischer Prüfdienst des Bundesamts für Eich- und Vermessungswesen, Austria (coordinator)

BFKH: Budapest Főváros Kormányhivatala, Hungary

CEA: Commissariat à l'énergie atomique et aux énergies alternatives, France

CMI: Cesky Metrologicky Institut, Czech Republic

IFIN-HH: Institutul National de Cercetare-Dezvoltare pentru Fizica si Inginerie Nucleara "Horia Hulubei", Romania

PTB: Physikalisch-Technische Bundesanstalt, Germany

STUK: Sateilyturvakeskus, Finland

VINS: Institut Za Nuklearne Nauke Vinca, Serbia

AGES: Österreichische Agentur für Gesundheit und Ernährungssicherheit, Austria

BfS: Bundesamt für Strahlenschutz, Germany

CLOR: Centralne Laboratorium Ochrony Radiologicznej, Poland

IRSN: Institut de Radioprotection et de Surete Nucleaire, France

JRC: Joint Research Centre - European Commission, Europe

SUJCHBO: Státní ústav jaderné, chemické a biologické ochrany, v.v.i., Czech Republic

SUBG: Sofiiski Universitet Sveti Kliment Ohridski, Bulgaria

UC: Universidad de Cantabria, Spain

METAS: Eidgenössisches Institut für Metrologie, Switzerland

MetroRADON collaborators

DiMEILA Centro Ricerche INAIL, Italy

EURADOS, international

Istituto Superiore di Sanità, Italy

LIFE-Respire-Consortium, international

Radonova, Sweden

University of Babeş-Bolyai, Romania

Universidade de Coimbra, Portugal

Universitat Politècnica de Catalunya, Spain

University of Novi Sad, Serbia

MetroRADON events

Harmonisation of radon measurements methodologies and radon priority areas

This 2-days workshop was organised by AGES and BEV and took place on 25-26 February 2020 in Vienna as part of the "European Radon week 2020", together with the European Commission JRC workshop "Challenges in the implementation of EU-BSS" and the European Radon Association (ERA)-workshop on "Radon Research". About 100 stakeholders from 29 countries participated on-site or online. The results of WP2/WP3/WP4 were presented in 23 talks and discussed with the stakeholders in group discussions. In addition an industry exhibition was included.

New procedures for radon monitoring

This 1-day workshop was organised by PTB and planned for May in Berlin. Because of Covid-19 it was postponed to 12 October 2020 and held as a web-conference. The results of WP1/WP2/WP5 were presented to about 70 stakeholders, followed by a round table discussion.

New procedures, guidelines and methodologies for radon instrument calibration and measurements

This 1-day training seminar was organised by UC and also postponed to 13 October 2020 and held as a web-conference. Results of WP2/WP5 were presented, specified for the audience of calibration facilities and end-users and with room for questions and discussions.

Transport of Radon and Thoron in Polymers

This workshop was organized by SUBG and took place on 21-22 March 2019 in Sofia. The outcomes and achievements of different groups and researchers engaged in research in this field were reported on the workshop.

More information and the presentations of the events can be found on the MetroRADON website.

Development of novel procedures for the traceable calibration of radon measurement instruments at low activity concentrations (WP1)

The aim of WP1 was the development of novel procedures for the traceable calibration of radon (^{222}Rn) measurement instruments at low activity concentrations (100 Bq/m^3 to 300 Bq/m^3) with relative uncertainties ≤ 5 % (k=1) and the results are described in the ***Deliverable D1***. This activity range is relevant for regulations defined by the European Council Directive 2013/59/EURATOM for indoor radon concentrations at workplaces (article 54) and dwellings (article 74).

Development of development of new ^{222}Rn and ^{220}Rn radioactive reference sources with stable and known radon emanation capacity

PTB, supported by JRC has developed ^{222}Rn and ^{220}Rn emanation sources including a detector system for the continuous monitoring of the emanated activity of ^{222}Rn relative to the activity of the ^{226}Ra source (and emanated ^{220}Rn relative to activity of ^{228}Th source) traceable to primary standards (**journal article published:** Mertes et al., 2020).

CEA has developed ^{222}Rn and ^{220}Rn emanation sources using polymers. The radon emanation of the sources is not quantitative. These sources were used by CEA and METAS for the development of a method for direct and traceable measurement of the activity concentration of ^{222}Rn and ^{220}Rn in an air flow (Figure 1).

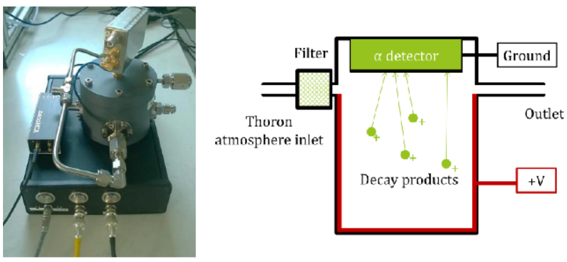

Figure 1: Set-up for measurement of activity concentration in an air flow at LNHB

CMI with support from SUJCHBO has developed a long term stable ^{222}Rn low activity emanation flow-through standard source based on a metering flow controller and dispenser generating a known ^{222}Rn concentration in an air flow.

The quantitative emanations from the two types of sources, developed at PTB and CMI, were compared with the results obtained with the "in air flow measurement system" developed at CEA.

Establishment of constant and stable ^{222}Rn radon activity concentrations in reference chambers and development of calibration procedures

The new ^{222}Rn emanation sources developed and compared within the project together with existing certified reference volumes were installed at BfS, BFKH, IFIN-HH, IRSN, METAS and SUJCHBO reference chambers in order to establish constant and traceable ^{222}Rn activity concentrations.

BfS, IFIN-HH, BFKH, IRSN, METAS and SUJCHBO developed calibration procedures for their reference chambers in the activity concentration range from 100 Bq/m³ to 300 Bq/m³ using ^{222}Rn gas and emanation standards (examples in Figure 1 and **open access journal article published**: Fialova et al. 2020). The result is not one single and unified calibration method but very similar methods using slightly different sizes of calibration chambers and a bit different instrumentation of sensors, flow controllers, etc. The comparability of the calibrations at the six mentioned facilities is documented in Deliverable D7 (see WP5). The goal to develop procedures for the calibration of radon measurement instruments at low activity concentrations (in the activity concentration range from 100 Bq/m³ to 300 Bq/m³) with sufficiently low relative uncertainties ≤ 5 % was reached. Time stable activity concentrations in this range have been established with the following uncertainties (k = 1) at: BfS with 1.0 %, IRSN with 2 %, METAS with 1.5 %, and SUJCHBO with 2 %. Long exposure times of about 40 hours were used to realize uncertainties of the calibration factors for radon measurement instruments close to the uncertainties of the activity concentrations.

The novel procedures for the calibration of radon measurement instruments at low activity concentrations were used to determine the accuracy of commonly used integrated radon measurement instruments (alpha-track detectors, electrets, etc.) and novel detectors.

After finishing the Deliverable D1, a new radon monitor type AlphaGuard DF2000 was purchased at IFIN-HH, using funding available from a national research project. In connection with the results obtained in the MetroRADON project, the new radon monitor will be used as a reference device and together with the radon chamber (1 m^3 volume) will allow to perform the calibration of the radon monitors belonging to the customers.

Comparison of existing radon gas primary standards at European NMIs/Dis in the few kBq range

The ^{222}Rn comparison is registered at EURAMET under the number 1475 and at BIPM as EURAMET.RI(II)-S8.Rn-222. Samples of ^{222}Rn gas provided by the LNE-LNHB were sent to the seven participants and were measured using various techniques. The results are reported in Pierre et al., 2020, *EURAMET Project N 1475-EURAMET.RI(II)-S8.Rn-222 Draft B*).

Influence of thoron and its progeny on radon end-user measurements and radon calibrations (WP2)

The aim of WP2 was to investigate and to reduce the influence of thoron (^{220}Rn) and its progeny on radon (^{222}Rn) end-user measurements and ^{222}Rn calibrations. All tasks/activities were successfully completed and progress beyond state-of the art was achieved. The research and research results are comprehended in ***Deliverable D2*** of the project.

The main topics addressed within WP2 were:

Creation of reference thoron atmosphere and study of thoron homogeneity in exposure chambers (**journal article published:** Mitev K. et al., 2020).

A thoron calibration exercise at 3 different thoron concentrations was performed. As a result the traceability of the secondary reference instruments of four WP2 partners was ensured to the reference thoron system created in CEA/IRSN.

An experimental study of thoron interference on the results of 16 active radon monitors and 19 passive radon detectors was carried out. It was found that in most of them the thoron interference is greater than 5% and in some of them it is greater than 20%. These findings confirm that many radon monitors/detectors have a problem with thoron interference and justify the **recommendation** made: The manufacturers of radon monitors/detectors should perform testing for thoron cross-interference of their radon instruments and should include this information in the

Figure 2: Examples for reference chambers (from left to right: SUJCHBO, BfS, BFKH, IFIN-HH)

The temperature dependence of response to radon/thoron of active and passive radon/thoron monitors and radon detectors was **studied (open access journal article published:** Pressyanov, D., Dimitrov, D., 2020)

An analytical review of potential techniques and materials to reduce the influence of thoron on radon measurements and calibrations was prepared.

The properties of different filters/foils/ membranes that could potentially serve as selective thoron barriers and assessment of their radon permeability were evaluated. The radon transport properties of different polymers were studied (**open access journal article published:** Georgiev S. et al., *2019*)

Selective anti-thoron barriers were characterised. The major findings are:

- Diffusion barriers introduce an additional inertia in the response of active detectors.
- Gaps/pin holes chambers do not isolate the detection volume from the humidity. For such chambers the thoron interference may vary in different detectors of one and the same kind;
- Polymer foils introduce a temperature bias in the radon results.

Recommendations on the construction of radon monitors that are not sensitive to thoron including the technical concepts/solutions aimed at reducing thoron-related bias in the radon signal in existing monitors were developed:

- Reducing the thoron interference is matter of finding the best compromise between anti-thoron protection ensured and worsening of some quality of the radon measurements;
- Different approaches to achieve the best anti-thoron protection of active radon monitors and passive radon detectors with no or minimum influence on the quality of radon response are proposed in Deliverable 2. In particular, an unexpected finding led to innovation that is progress beyond stat-of-the-art: possibility to reduce or compensate the thoron interference + temperature related bias + humidity influence for many widely used detectors (potentially for all detectors which radon response decreases with the increase of the temperature; **patent application submitted:** Pressyanov, D., 2019. Bulg. Pat. Appl. Reg. Nr. 112897, priority: 19.03.2019, WIPO Appl. Reg. Nr. PCT/BG2020/000003), see Figure 3.

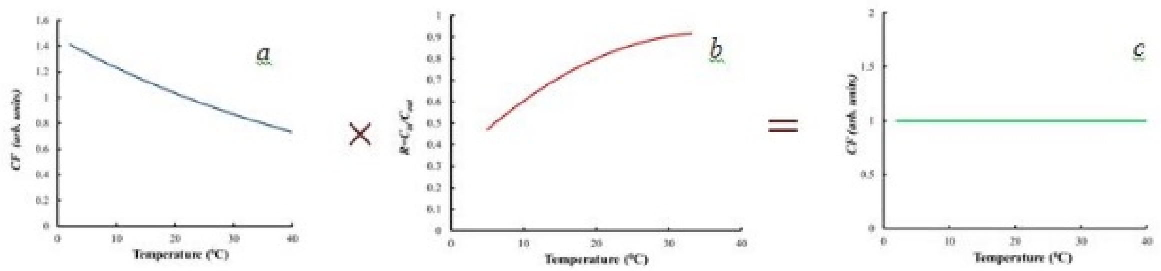

Figure 3: The concept of the compensation module design (patent pending): The temperature dependence of the response of many radon detectors (a) and that introduced by polymer anti-thoron barriers (b) are reciprocal. This can be used to reduce/eliminate the temperature dependence (c), the thoron interference and the humidity

Comparison and harmonization of radon measurement methodologies in Europe (WP3)

The aims of WP3 were to collect and analyse meta-information on radon surveys performed and existing radon databases in European countries, to evaluate if the data and methodologies are comparable and how they could be harmonized in case of methodical inconsistency. The results obtained in this WP are reported in ***Deliverable D3*** and ***Deliverable D4***.

Deliverable D3: *"Report on indoor and geogenic radon surveys in Europe, including their strategies, the methodologies employed,* inconsistencies *in the results, and potential methodologies to harmonise data and reduce inconsistencies"*

Overview and analysis of indoor radon surveys in Europe

Conclusions from both literature overview and questionnaires performed on indoor radon surveys in Europe are that the overall design of surveys is quite diverse and that it is difficult to find two completely same approaches to a survey. By looking at 3 main aspects of the survey it can be summarised that: a) designs of surveys performed in Europe are not comparable; b) measurement methods are comparable between surveys; c) data management, statistical analysis and mapping are for some aspects comparable for others not.

The most critical part of the surveys was estimation of representativeness. An important aspect in harmonisation is to apply seasonal corrections. Furthermore, a non-negligible effect of reported indoor radon concentrations could be due to thoron influence. A **JRC technical report** (Pantelić et al. 2018) and an **open access journal article (**Pantelić et al., 2019) were published**.**

Overview and analysis of geogenic radon surveys in Europe

Relatively much information is available on the status of geogenic radon surveys in European countries, as well as about methodology. On the other hand, not many countries have performed geogenic radon surveys; therefore, European coverage is poor. Again, on the other hand, surveys and data sets about quantities, which can serve as predictors (U concentration) or proxies (Ambient Dose Equivalent Rate) of the Geogenic Radon Potential, are available in many countries. So far, the data have been exploited for generating European wide geogenic radon map only in experimental trials. Current work seems more focused on developing a geogenic radon hazard index (GRHI) which relies on Europe wide available data bases (such as for geology and geochemistry), rather than on assembling regional un-harmonized datasets. Regarding methodical harmonization of geogenic quantities, a few issues have been identified. The problems can be solved, but in some cases require further experiments and partly development of procedures for harmonization.

Method of retrospective indoor radon measurements using CDs/DVDs

The method employs CDs/DVDs as radon detectors (from the available stock stored indoors) and provides long term (> 1 year) retrospective indoor radon concentration results.

The main directions of usage of the CD/DVD method can be summarized as:

- retrospective dosimetry of radon and thoron (incl. for the purposes of radon mapping);
- identification of radon prone areas and buildings with radon problems;
- retrospective evaluation of the effect of building retrofits on radon levels;

- measurements in working places (incl. mines);

Deliverable D4: *"Report on the results from the on-site comparison of indoor radon measurements and geogenic radon measurements under field conditions together with guidelines/recommendations to assist the implementation of the EU-BSS"*

Intercomparison Exercise

An intercomparison exercise has been carried out by the University of Cantabria with the support of JRC in the Laboratory of Natural Radiation (LNR) located at the facilities of the former uranium mine managed by the Spanish National Uranium Company ENUSA (Ciudad Rodrigo, Salamanca, Spain). Twenty participants from 13 countries took part in the intercomparison **"radon in air"**, three in the "**radon exhalation from soil**" and five in the "**radon in soil**" exercise. Over 80 % of the results for radon-in-air exposure are within the interval defined by the reference value and the standard deviation. Results are published in an **open access journal article** (Rabago et al., 2020)

Development of options for harmonization of indoor and geogenic radon data including practical examples

Collection of radon data is the first step in the development of any kind of radon maps. Several kinds of radon maps can be created that display for example the simple arithmetic mean, % above reference level, radon potential, radon priority map, radon hazard index map. Therefore, the input radon data will strongly influence the output map. Radon data could be: indoor radon, soil gas radon, geogenic radon data (uranium concentration in soil and rock, terrestrial gamma dose rate, soil permeability, radon in water).

Different surveys – data can be harmonized in two ways as displayed in Figure 4. Firstly, all surveys are performed methodically identically. Then homogeneity is ensured by construction - this approach is called *bottom-up* and viable only if surveys are planned jointly from scratch. Realistically, surveys are conducted independently (different period, different purpose, different methods, etc.). To make surveys comparable, the results need to be normalised to a common standard using models based on physical and statistical knowledge of the used procedures in the survey. This is called *top-down* or posterior harmonization.

Our conclusion is that harmonization of radon data is partly possible and projects like MetroRADON and intercomparison exercises are needed to study the comparability of radon data and develop procedures for harmonization. However, it is not an easy task and further studies of comparability and harmonization should be performed in the future.

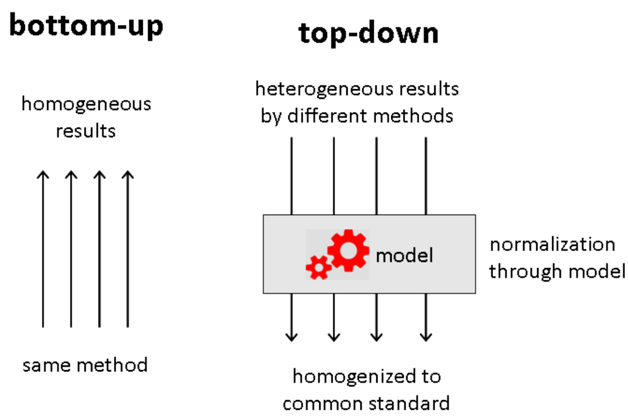

Figure 4: Bottom-up and top-down harmonization

Radon priority areas (RPAs) and the development of the concept of a geogenic radon hazard index (WP4)

The aim of this work package is to analyse and develop methodologies for the identification of radon priority areas, to investigate the relationships between indoor Rn concentrations and quantities related to geogenic Rn, including soil exhalation and to develop the concept of a "geogenic radon hazard index" (GRHI) as a tool to help identify radon priority areas. In the following the work and results of two main activities in the last months are summarised. The results obtained in this WP are reported in ***Deliverable D5*** and ***Deliverable D6.***

Deliverable D5: *"Report and Guideline on the definition, estimation and uncertainty of radon priority areas (RPA)"*

Evaluation of the concepts for the definitions of radon priority areas (RPA)

As a conclusion of this task, it appears that conceptual and theoretical work about is well advanced. Their generic definition according BSS is an area in which a significant proportion of indoor radon concentrations exceeds a reference level of 300 Bq/m³, at most. An important result is the comparison of residential buildings and workplaces regarding their radon characteristics. These were found to be different, in general. This is relevant, because RPAs are mostly estimated based on data of indoor radon concentration in dwellings, but legal consequences as stated in the BSS largely pertain to workplaces. For evaluating the cross-usage of concepts, different mapping methods were compared. Applying a mapping method using data sets, which were not designed for the specific requirements of the mapping method, is challenging. Different mapping methods often, but not always, deliver the same results in RPA classification, depending on the definition of RPAs. Definition of thresholds is a key factor in delineation of RPAs.

Relationship between indoor radon concentration and geogenic radon

Different concepts of radon potential (RP) were reviewed in this task. One may distinguish between "top-down" approaches, whose initial variable is observed indoor Rn concentration and "bottom-up" approach, which starts from control quantities. The GRP (geogenic radon potential) is a particular kind of RP; it is defined physically from geogenic quantities which control Rn generation and transport in the ground. Regarding mapping, the rationale of the RP in general and the GRP in particular is that the geographic pattern of IRC (indoor Radon Concentration) mainly reflects the one of its geogenic controls.

The often poor correlations between IRC and geogenic quantities remain a challenge for further studies. Regionally developed models may not be applicable beyond the region in which they have been developed. First European-scale studies about that problem have been initiated only recently. An open question is the one of anthropogenically modified geogenic factors. This is important because most people live in altered built-up environments. It is recommended that the topic is addressed thoroughly in future investigations.

Harmonisation of radon priority areas across borders

Comparisons of some examples of borders in Europe show different mapping methods and different mapping results. Main sources of inconsistency are underling data and RPA definition, as well as estimation methodology. Further studies are still necessary in European Countries to provide the technical explanations of consistency or inconsistency between maps across borders, as a condition to credible communication to the public.

Deliverable D6: "*Report on the concept and establishment of a Radon Hazard Index (GRHI) including an RHI map of Europe showing areas with high geogenic radon potential and conclusions on the relationships and correlation between indoor Rn concentration and quantities related to geogenic Rn"*

New developments in estimation of radon priority areas

Quality assurance of RPA delineation is often ignored. As results of an estimation procedure, RPAs are uncertain, in the sense of misclassification. This uncertainty cannot be avoided by nature of statistics, but it should be quantified. Several methods have already been developed to map RPAs. A complementary approach was tested to focus on the identification of areas that could be concerned by a significant proportion of dwellings with very high IRC of several thousands of Bq/m³. The results provide first useful elements to target areas where more precise studies are needed. An analysis of both geological features and building characteristics to identify the best indicators of highest indoor radon values is lacking. Such a method would allow developing specific prevention and remediation actions in heavily affected regions to significantly reduce the exposure in buildings.

The GRHI can be understood as a generalized complement and extension to the GRP to characterize susceptibility of a location to geogenic radon, as one important control of indoor Rn. The GRHI is more flexible and can deal with data which usual GRP definitions cannot handle. Its main application is thought to be large-scale mapping, i.e. on European scale (Fig.5), in contrast to small-scale characterization, whose objective is supporting legislative and administrative implementation of the BSS.

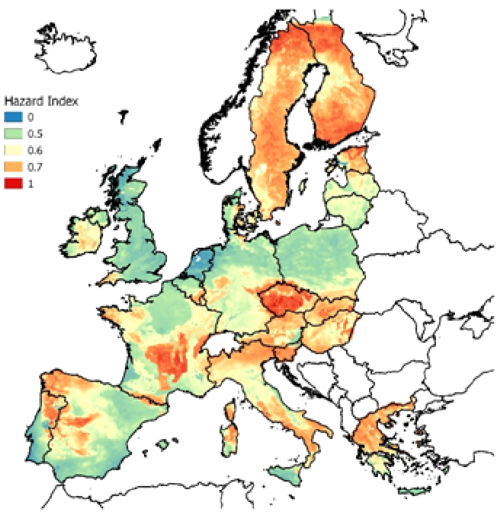

Figure 5: A tentative European GRHI map (from Bossew et al. (2020), Generated by machine learning based on numerous geogenic quantities

Open problems identified in WP 4

During the work in WP 4, a number of open questions were identified, whose investigation would improve estimation and mapping of radon priority areas.

- In many instances, available data of IRC are not sufficient for regionalized RPA estimation. Therefore, IRC predictor controls and proxies are included in estimation. This leads to the necessity of **regression models** and geostatistics.
- The matter is closely related to the one of spatial (geographical) properties of **anthropogenic factors**. While the geogenic factors have been relatively well explored, this is not the case for the anthropogenic factors.
- The GRP is composed of radon source and radon transport. Their values acquired by grab sampling in the field reflect the condition at a certain time, which may be **temporally variable** to different extent. Solutions to be evaluated and compared more thoroughly include resorting to long-term measurements or fostering modelling based on temporally stable quantities.
- One alternative to the GRP is the **radon hazard index RHI** (its geogenic specification, GRHI). The concept and possible variants have been introduced in MetroRADON.
- Radon quantities, notably IRC and GRP, tend to spatially and temporally extreme behaviour, resulting in the occurrence of **local anomalies**. The question how to estimate and map anomalies adequately will remain an issue due to its statistical complication.
- **Residential buildings and workplaces and public buildings** have different physical characteristics, in general, in particular concerning their “response” to geogenic Rn. It turned out that the matter

is complex and should be investigated further due to its practical importance.

- Questions of more political nature pertain to **stakeholder** interests. These largely determine delineation of RPAs. The process of national implementation of the BSS will result in a patchwork of RPA definitions across Europe. To assess consistence of RPAs, or its lack, will remain on the agenda.
- It is common in some areas that workers commute between countries and work in- and outside differently defined RPAs. Countries may have different criteria when it comes to **dose evaluation.**

Work on WP4 led to a number of publications. 4 peer-reviewed papers (see references in this newsletter) have been published, 3 more are currently in work. Between 2018 and 2020, WP4 participants attended 12 scientific conferences in 8 countries with 33 presentations. All publications can be found on the MetroRADON webpage.

Validation of traceability of European radon calibration facilities (WP5)

The aim of WP5 is to validate the traceability of existing European radon calibration facilities over the ranges from 100 Bq/m^3 to 300 Bq/m^3 and 300 Bq/m^3 to 10 000 Bq/m^3. International comparisons were performed that will fulfill the need to provide confidence in the capability of European radon calibration facilities in the field of radon activity concentration measurements in air. A significant improvement in the metrological infrastructure in Europe in the field of radon calibrations at low activity concentrations have been achieved within MetroRADON in order to be able to fulfil the EU-BSS requirements. The results of the performed validations and results from the questionnaire are summarized in the ***Deliverable D7*** "Validation report on the traceability of primary and secondary radon calibration facilities in Europe" and the ***Deliverable D8*** *"*Guideline and recommendations on calibration and measurement procedures for the determination of radon concentration in air".

Identification, evaluation and selection of European radon calibration facilities for validation of traceability

The first task was to mapping the relevant European radon calibration facilities. The main objective was to be able to serve European radon calibration facilities in a better way by identifying needs and work on solutions to that. For this purpose a questionnaire was created. The questionnaire asked for the performance of the laboratory and the traceability of the quantity radon activity concentration and it was divided into two parts: information about laboratory and laboratory performance and traceability. About 25 relevant European radon calibration facilities were asked to complete the questionnaire and we have received 18 answers to the questionnaire. Following information was evaluated based on the results from the questionnaires: legal forms of laboratories, accreditation status, radon activity concentration measuring instruments which represent the highest metrological level, working standards, methods of calibration, calibration ranges, the uncertainties of calibration capabilities, size of radon chamber, climatic conditions, some additional parameters which can be monitored or controlled and the number of calibrations. This survey was comprehensive. The highest level radon concentration measuring instruments are AlphaGuards.

Validation of the traceability, performance and precision of European radon calibration facilities

In the framework of MetroRADON interlaboratory comparisons were initiated in order to validate the traceability of European radon calibration facilities and to demonstrate their performance in calibrating radon measuring instruments in the ranges from 300 Bq/m^3 to 10 000 Bq/m^3 (coordinator BfS) and 100 Bq/m^3 to 300 Bq/m^3 (coordinator SUJCHBO). Calibration services from different EU member states, which preferably represent the respective national reference for the quantity radon activity concentration in air, were encouraged to participate in the comparison. The objective of the interlaboratory comparisons was to determine the degree of agreement in the realization of the activity concentration of radon-222 in air in the facilities of the participating laboratories and to create links between selected laboratories. The traceability chains of the quantity radon activity concentration in Europe were outlined.

In total 15 calibration facilities from 12 different countries of the European Union and one from Montenegro (MNE) participated in the interlaboratory comparison in the range from 300 Bq.m^{-3} to 10 000 Bq.m^{-3}. The interlaboratory comparison was conducted by the German Federal Office for Radiation Protection (BfS) and took place in the period from March 2018 to February 2020.

Another verification of secondary standards of European calibration laboratories was performed by SÚJCHBO, v.v.i. Kamenna at stable radon atmospheres in the range from 100 Bq.m^{-3} to 300 Bq.m^{-3} from October 2019 to April 2020. Eight European laboratories have participated in the intercomparison of secondary standards and nine measuring devices were calibrated.

The considerable number of participants from various European countries with different positions in the metrological hierarchy and thus different positions in the traceability chain of the considered quantity allowed a representative validation of the performance and quality in the calibration of radon measuring devices. Figure 6 shows the countries where laboratories participated in the comparisons.

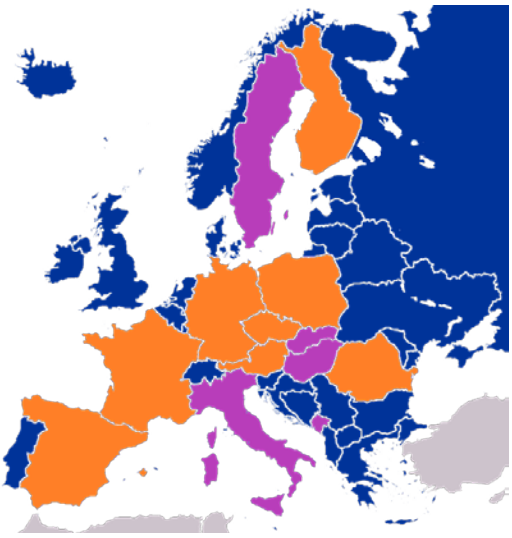

Figure 6: Calibration facilities participating in interlaboratory comparisons (violet – laboratory participating only in comparison performed by BfS, orange – laboratory participating in comparisons at BfS and SUJCHBO)

The traceability and quality assurance of calibrations of radon monitors and of radon calibration facilities itself as well as the development of methods to conduct a large number of traceable and quality assured in-situ and laboratory measurements of radon has been concerned within the MetroRADON project. The electronic instruments of the type AlphaGUARD were selected as the comparison devices. The devices were compared to each participant's secondary standard, which are used for the calibration of the end-user devices.

The interlaboratory comparison of secondary standards of European radon calibration facilities for radon calibration is a powerful tool to detect discrepancies in traceability and to ensure the quality of radon measurements in Europe. It is strongly recommended to carry out the calibrations and verifications regularly.

MetroRADON publications

Papers, Deliverables, activity reports, presentations, posters can be also found in the Documents Section on the MetroRADON website.

A list of already published papers and external reports is given here:

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