



Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety



Radon action plan

for the sustainable reduction of radon exposure

Publication details

Published by

Federal Ministry for the Environment, Conservation and Nuclear Safety (BMU)
Division for Public Relations, Online Communication and Social Media · 11055 Berlin · Germany
Email: buergerinfo@bmu.bund.de · Website: www.bmu.de/english

Edited by

BMU, Division S II 2

Design

design_idee, büro_für_gestaltung, Erfurt

Printed by

Druck- und Verlagshaus Zarbock GmbH & Co. KG, Frankfurt am Main

Picture credit

Cover: magicbeam/Stock.Adobe.com

Date

March 2019

First print run

500 copies (printed on recycled paper)

Where to order this publication

Publikationsversand der Bundesregierung
Postfach 48 10 09 · 18132 Rostock · Germany
Tel.: +49 30 / 18 272 272 1 · Fax: +49 30 / 18 10 272 272 1
Email: publikationen@bundesregierung.de
Website: www.bmu.de/en/publications

Notice

This publication of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is distributed free of charge. It is not intended for sale and may not be used to canvass support for political parties or groups. Further information can be found at www.bmu.de/en/publications

Rn

Radon action plan

for the sustainable reduction of
radon exposure

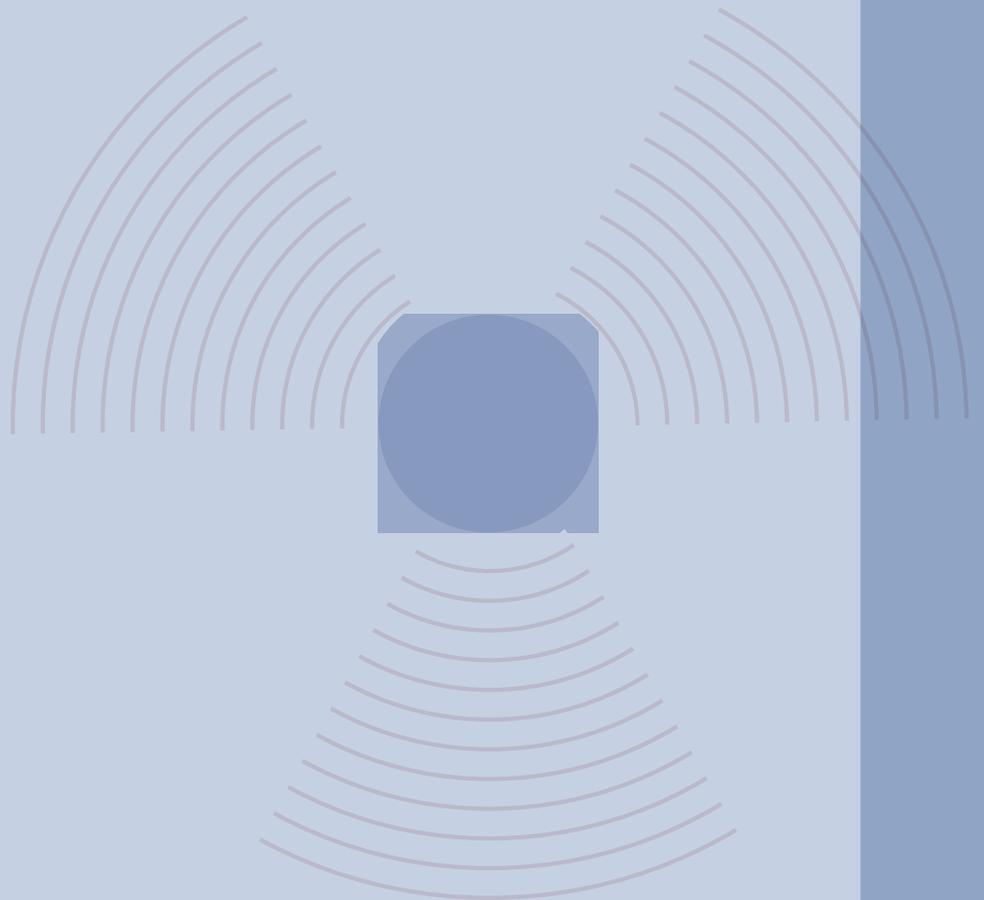
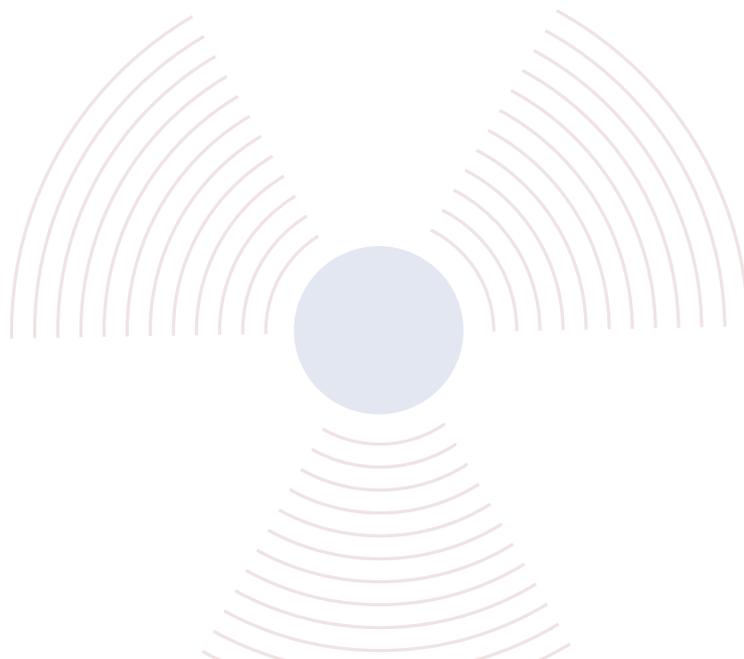


Table of contents

I	Introduction	6
II	Radon protection measures	9
II.1	Public relations work	10
II.2	Survey of radon occurrence and identification and designation of radon prone areas	13
II.3	Measures to prevent or significantly impede radon ingress into habitable rooms in new buildings	16
II.4	Measures to reduce radon activity concentration in the air in existing buildings	18
II.5	Radon in the workplace	20
II.6	Research on radon and protective measures	22
II.7	Precautionary measures regarding radon in drinking water	22
II.8	Evaluation of implementation of measures	23

III	Evaluation of the action plan and status of implementation of measures	24
IV	References	25
	Annex: Description of measures	26
	List of abbreviations	39



Introduction

I

Radon¹ is a naturally occurring radioactive noble gas. It is invisible, has no smell or taste and is an intermediate product of the decay of radioactive materials that naturally occur in soil, building materials and water. Due to its gaseous state, radon can leak out of these materials and accumulate in the indoor air, particularly when a sufficient ventilation has not been ensured in the building. The largest share generally comes from radon in the soil, which seeps in through pathways in buildings. The accumulation of radioactive radon decay products in the lungs and the decay of the remaining radon in the body are the second leading cause of lung cancer in Germany, after smoking tobacco.

There is a statistical correlation between radon activity concentration in the air and the harmful effect of radon exposure and its short-lived decay products. Radon activity concentration in air is measured in becquerels per cubic metre (Bq/m³). One becquerel per cubic metre corresponds to one radioactive decay per second and per cubic metre of air. Scientific studies have demonstrated that there is a statistically significant increase in the risk of lung cancer associated with radon activity concentrations above 100 becquerels per cubic metre (Darby 2005). The relative risk of lung cancer increases by approximately 16 percent per 100 becquerels per cubic metre. The average radon activity concentration in homes in Germany is about 50 becquerels per cubic metre (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety [BMUB] 2017a).

1 Throughout this document, when radon is referred to it is the isotope radon-222, specifically, that is meant. This isotope is a decay product of radium-226 and is one of the nuclides in the naturally radioactive decay chain of the parent nuclide uranium-238.

Legal basis and objectives of the radon action plan

As part of the implementation of European Council Directive 2013/59/Euratom (Euratom 2013), the Radiation Protection Act² (Strahlenschutzgesetz - StrlSchG) was adopted in Germany. The act was further specified in the new Radiation Protection Ordinance³ (Strahlenschutzverordnung - StrlSchV).

In addition to a comprehensive revision and the extension of provisions on radon protection in workplaces, the Radiation Protection Act contains provisions, for the first time, on protecting the public against radon in habitable rooms. A reference level of 300 becquerels per cubic metre now applies to annual radon activity concentration both in habitable rooms and in indoor workplaces. A reference level is a specified level used as a benchmark to review the appropriateness of measures. A reference level is not a dose limit. According to the optimisation principle laid down in radiation protection, taking all circumstances of the individual case into consideration, it should be sought to keep exposure as low as reasonably achievable, also below the reference level. The reference level of 300 becquerels per cubic metre follows the values specified in Article 54(1) and Article 74(1) of Directive 2013/59/Euratom. This is also in line with the requirements of the World Health Organization for countries in which a reference level of 100 becquerels per cubic metre is not feasible due to specific national circumstances (World Health Organization [WHO] 2009), and with the requirements of the International Commission on Radiological Protection (ICRP 2014) and the International Atomic Energy Agency (IAEA 2014).

The provisions of the Radiation Protection Act on radon protection entered into force on 31 December 2018. In accordance with section 122 (1) of the Radiation Protection Act, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has to prepare a radon action plan with the participation of the federal states (Länder). The action plan outlines the measures in accordance with the Radiation Protection Act and contains goals for addressing the long-term risks of exposure to radon in inhabitable rooms and indoor workplaces from all radon sources, be it from the soil, construction products or water. It describes the intended course of action of the federal government and the federal states and provides experts and interested citizens with information on the strategy to reduce radon exposure in Germany.

The measures presented below are intended to sustainably reduce the number of lung cancer cases caused by exposure to radon and its

-
- 2 Article 1 of the Act on the reform of legislation for protection against the harmful effects of ionising radiation of 27 June 2017 (Gesetz zur Neuordnung des Rechts zum Schutz vor der schädlichen Wirkung ionisierender Strahlung) (Federal Law Gazette I page 1966).
 - 3 Article 1 of the Ordinance on the further modernisation of radiation protection legislation of 29 November 2018 (Verordnung zur weiteren Modernisierung des Strahlenschutzrechts) (Federal Law Gazette I page 2034).

short-lived decay products. To achieve this goal, habitable rooms and workplaces with high radon activity concentration in the air need to be identified and measures taken to reduce average radon activity concentration in the indoor air in buildings throughout Germany. Furthermore, research, development, education, further education and training are to be driven forward to ensure that the best possible radon protection can be offered in the future and long term.

Section 121 (1) first sentence, of the Radiation Protection Act stipulates that areas in which it is expected that the reference level will be exceeded in a significant number of buildings must be identified. This serves to achieve a targeted reduction of high radon activity concentration in the air in habitable rooms and workplaces. In addition, exposure to levels of radon which exceed the reference level for workplaces in particular is to be avoided.

To reduce average radon activity concentration in buildings in Germany, the public is to be informed of the risks of radon. This will enable the public to take voluntary measurements and implement radon protection measures if deemed necessary (for example airing more frequently, sealing pathways where radon seeps through and other construction measures). Radon protection, among other things, also should become an aspect to be considered in quality assurance and financial support measures for construction projects.

Research, development and education, training courses and further education in the field of radon protection are to be advanced to ensure that the latest scientific knowledge regarding the assessment of health effects and exposure of the public to radon is available. Moreover, generally acknowledged rules of technology for construction measures to protect against radon are to be established. Those involved in the planning and execution of building construction must have the possibility to acquire the knowledge and experiences required to effectively implement and further develop radon protection.



Radon protection measures

II

Measures to protect against exposure to radon in habitable rooms and workplaces range from general information and awareness raising measures to concrete technical measures. Technical measures in this context range from measures to prevent or reduce radon ingress into buildings to measures that reduce already existing high radon activity concentration in buildings.

The following sections describe the basic strategy to protect the public and workers from radon exposure and outline the measures to be implemented. A description of the requirements of each individual measure can be found in the annex with details of the planned implementation schedule and actors involved in implementation. National and international knowledge and experience are to be incorporated into the implementation of the measures.

- **Section II.1** presents the methods for communicating basic information on radon to the public.
- **Section II.2** describes the approach used for identifying areas in Germany for which there is an increased probability that the reference level for habitable rooms and in workplaces will be exceeded. This allows for a prioritised approach to the protection of the public against radon as more far-reaching measures are required in these areas, for instance at workplaces and for the construction of new buildings.

- **Section II.3** elaborates on construction measures to minimise radon activity concentration in indoor air in new buildings.
- **Section II.4** describes construction measures to reduce radon activity concentration in indoor air in existing buildings.
- **Section II.5** deals with radon protection in workplaces.
- Research on radon and associated protective measures is examined in **section II.6**.
- Existing provisions on protection against radon in drinking water are summarised in **section II.7**.
- **Section II.8** looks at the analysis and assessment of the effectiveness of measures after implementation.

Any additional requirements should be compensated in the area of the federal government, financially and in the form of positions, in the respective individual budgetary plans.

II.1 Public relations work

There is often little awareness among the public regarding the health risks of radon exposure. To make this topic accessible to the wider public and to make the associated legal provisions more understandable, comprehensive measures to inform all relevant target groups need to be initiated. The objective is to make comprehensive information available to the public on the health impacts of radon, on how to measure radon and on possible construction measures to protect against radon.

For existing buildings and in so far as no workplaces are affected⁴, legal provisions on radon protection do not lay down any binding obligations for the parties responsible for the buildings. Rather, emphasis is placed on promoting individual initiative through suitable public relations work. Section 125 of the Radiation Protection Act stipulates that the BMU and the competent authorities of the federal states must provide the public with information, in an appropriate manner, on exposure to radon in

4 With regard to workplaces, the party responsible for the workplace may, under certain circumstances and where required by the applicable legal provisions, be obliged to take measures to reduce radon activity concentration.

habitable rooms and the associated health risks, on the importance of radon measurements and the technical possibilities available to reduce existing radon activity concentration. Furthermore, it is stipulated that the aforementioned institutions are to take measures to identify habitable rooms in which average annual radon activity concentration in the air exceeds the reference level laid down in section 124 of the Radiation Protection Act, and recommend technical or other means of reducing radon exposure.

The benchmark for radon protection are the reference levels for radon activity concentration in habitable rooms and workplaces, both of which have been set at 300 becquerels per cubic metre (annual average). Measures are to be planned and carried out at federal and federal state (Land) level, which

- help raise widespread awareness of the health risks of radon, also in connection to smoking, among the public and relevant stakeholders with decision-making powers,
- provide information on the importance of measuring radon activity concentration in indoor spaces and the simple and cost-effective options available for doing so and
- offer guidance and support on how to deal with occurrences of high radon activity concentration for example in the form of behaviour guidelines, structural changes or other measures.

To ensure that the relevant information and recommendations for action reach the members of the public affected, as many media options as possible should be used (for example information booklets, instruction leaflets, internet presentations, social media and targeted campaigns). Suitable multipliers and communication channels are to be identified on the basis of target group analyses. Building on this, communications strategies should be developed in a way which ensures that basic initial information reaches as much of the public as possible. One focus of these strategies must include references to more detailed information available, for example online or in information leaflets. Multipliers, this means people or institutions that pass on knowledge or information, therefore play a very important role here. Teaching staff, municipal authorities and personnel in health professions as well as experts in the field of construction and participating media and associations are all potential multipliers that could disseminate information. The entire range of expert information available on radon and radon protection has to be integrated into the development of communication strategies. For this reason, multipliers and participants from the affected associations should be involved in the development of communication strategies and mutual exchange should be encouraged. ►

The way in which a risk is perceived is a decisive factor in the motivation to inform and, if necessary, protect oneself. With respect to radon, this

Measure 1.1:

Identify target groups, multipliers and target group-appropriate communication channels to provide information on radon

Measure 1.2:

Prepare resources to support an easier understanding of the health impacts of radon

means: inform oneself, take measurements and, if necessary, take remedial steps or construction measures to protect against radon. The risk of developing lung cancer from radon therefore has to be presented clearly and comprehensibly, for instance in comparison to other health risks in indoor spaces and in relation to other, comparable cancer risks. An appropriate presentation of risks forms the basis for informing the public. To this end, the core aspects of communicating the consequences of long-term radon exposure have to be prepared at federal level with the participation of the federal states and, if necessary, multipliers and experts. ◀

Measure 1.3:

Develop and implement a nationwide public relations strategy to create basic understanding of radon among the public

To create a basic understanding of radon among the public, a nationwide public relations strategy is required. It must be aimed at sensitising and raising awareness and be developed together with the federal states and in coordination with federal state-specific strategies (see measure 1.4) and, if applicable, strategies to raise awareness of other health-related issues. Providing the public with information has to be carried out both at federal and federal state level. To this end, target group-specific and federal state-specific information material must be made available and target groups addressed specifically, for instance private persons or businesses. In particular, small and medium-sized enterprises, where it cannot be assumed that they have an in-depth knowledge of this topic, have to be provided with information through these strategies. ◀

Measure 1.4:

Develop federal state-specific public relations strategies which take account of regional radon exposure conditions

Communication measures such as information events and target group oriented information material are means of motivating groups of people working in the construction sector, the parties responsible for buildings, other affected parties addressed and multipliers to take action. Existing information material must be periodically updated and made available to the public at federal state and, if applicable, also at federal level. The natural occurrence of radon varies considerably both within a federal state and from one federal state to another. It is therefore necessary for each individual federal state to develop an appropriate public relations strategy to inform the regional population about radon in a suitable manner. The strategies must be adapted to each federal state's needs, however the content shall be coordinated with other federal states and the federal government. This will ensure uniform public communication and information. ◀



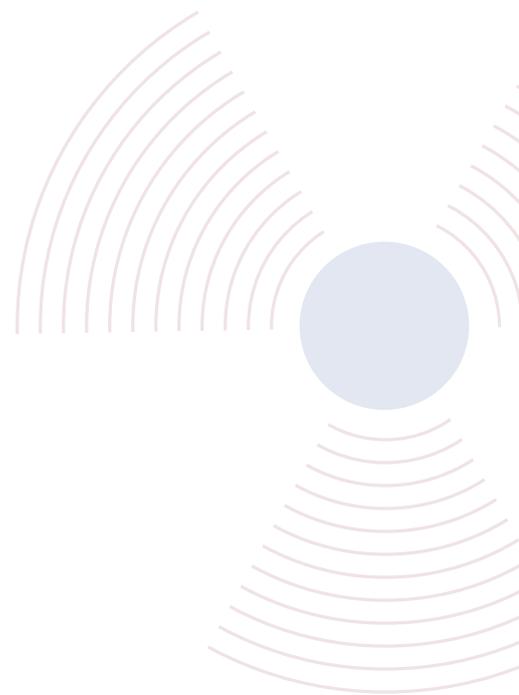
II.2 Survey of radon occurrence and identification and designation of radon prone areas

Section 121 (1) first sentence of the Radiation Protection Act obliges the competent authority, by means of a general order within two years after entry into force of the provisions under section 153 of the new Radiation Protection Ordinance, to identify areas in which it is expected that the average annual radon activity concentration in the air will exceed the stipulated reference level in a significant number of buildings with habitable rooms or workplaces. These areas are referred to as radon prone areas.

To identify these areas, regional spatial distributions of radon must be determined. This is to be based on measurements and estimates. A suitable data base needs to be created which can be used to identify radon prone areas. In addition, the infrastructure for designating these areas must be created (for instance a database for recording data and geostatistical methods for evaluating the data).

To facilitate a nationwide estimation of potential regional radon exposure in habitable rooms and workplaces, direct measurements of radon activity concentration in habitable rooms can be used or other data that allows conclusions to be drawn regarding radon activity concentration in indoor spaces from data based on scientific methods. Geological, geophysical and geochemical data is particularly suitable for this purpose. For example, measurement data for radon activity concentration in soil gas and soil gas permeability can be combined to calculate the parameter radon potential. This parameter can be used to estimate the distribution of radon activity concentration in indoor spaces using statistical methods. For parts of Germany, measurements were taken in the past for radon activity concentration in indoor spaces, radon activity concentration in soil gas and soil gas permeability. In parts of the country, the number and density of the measurement locations are adequate to calculate an initial, reasonably reliable estimate of radon potential. In other parts, further data is still required. Uncertainties in radon potential estimates can be attributed to natural regional availability of data and the regional variability of radon potential.

Approaches to the further analysis of radon potential in soil are to be developed, planned and implemented on the basis of current knowledge on the local distribution of radon activity concentration in soil gas, soil gas permeability and radon activity concentration in indoor air and on soil and rock type. The objective of this approach must be to determine whether the radon potential in an area is significantly higher than the national average.



The measures for surveying radon occurrences and identifying and designating radon prone areas are described below (measures 2.1 to 2.7). A diagram with an overview of these measures can be found in figure 1.

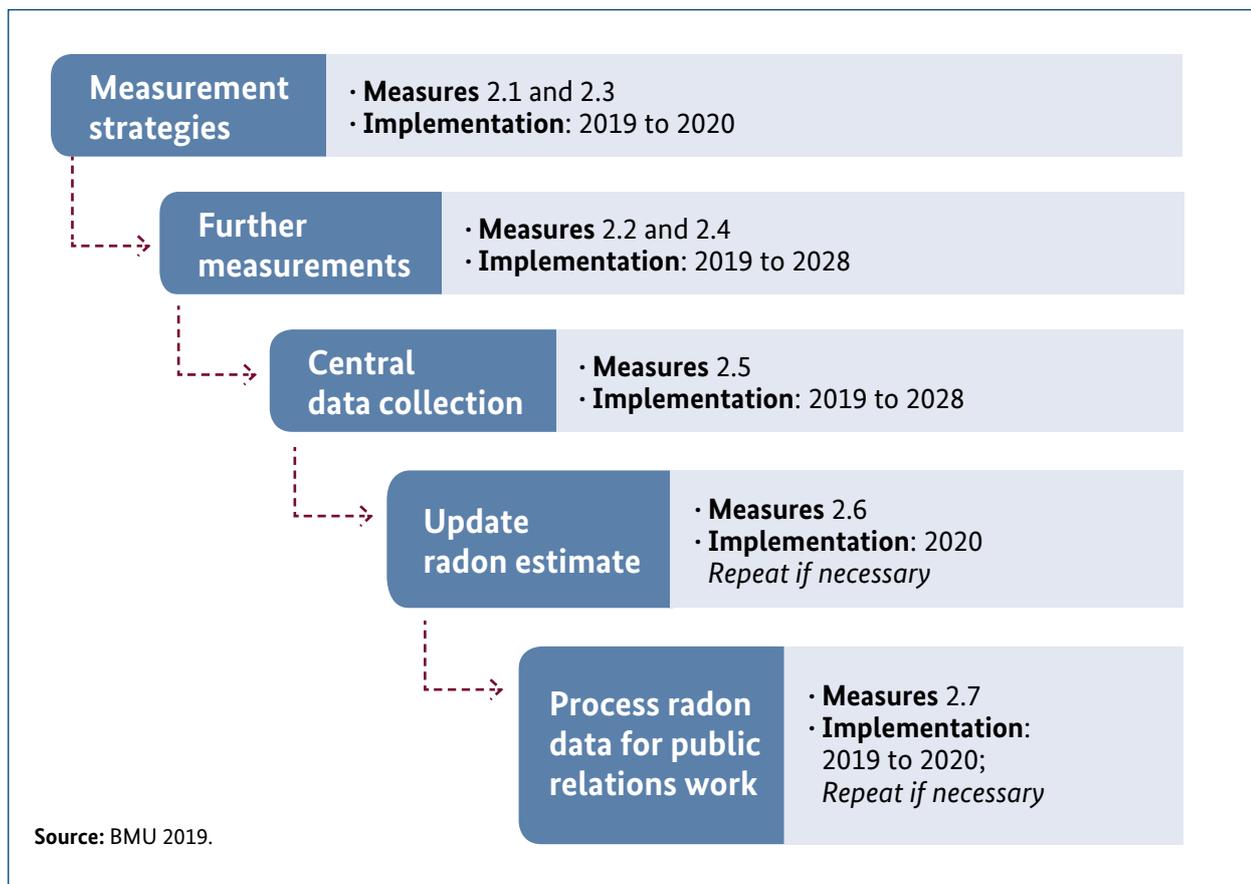
Based on radon potential and other suitable data, the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz – BfS) is to prepare an estimate for Germany which can be used to determine whether in a specific area it can be expected that the reference levels stipulated under sections 124 or 126 of the Radiation Protection Act will be exceeded in a significant number of buildings with habitable rooms or workplaces.

Measure 2.1:

Develop uniform measurement strategies and measures for quality assurance for measuring radon activity concentration in soil gas and soil gas permeability

The first step has to be to improve the data basis where necessary. To do this and to ensure a comparable quality of data, uniform measurement strategies and quality assurance procedures are to be laid down. These shall be drawn up and documented by the BfS together with the federal states. ◀

Figure 1: Overview of measures for surveying radon occurrence and identifying and designating radon prone areas (measures 2.1 to 2.7)



Further measurements of radon activity concentration in soil gas and measurements of soil gas permeability are to be taken. For comparably small-scale administrative bodies to designate radon prone areas, considerable measuring effort is required in some regions. This must therefore be an endeavour to be implemented over a longer period of time aimed at analysing radon occurrence underground. In addition, the possibility of establishing other methods, particularly for local area designation, are to be reviewed. ►

Measurements of indoor radon activity concentration in residential buildings and buildings with public access are to be taken to improve estimates for the designation of areas and to evaluate areas already identified as radon prone areas. The uniform measurement strategies and methods required for this are to be coordinated at federal level and developed with the involvement of experts from the federal states. To ensure better comparability of data, the measurement strategies are to be used as the basis for a series of measurements to collect data on indoor air radon activity concentration. The measurement strategies could also be used for measurements carried out voluntarily, for instance by private home owners, to estimate whether the reference level under section 124 of the Radiation Protection Act is complied with. ►

Taking further measurements of radon activity concentration in indoor air will enable more reliable predictions to be made regarding the levels and distribution of indoor radon activity concentration in Germany. The measurements are also required for area designation, which is why they should be carried out nationwide. Financial support instruments to carry out measurements, particularly in habitable rooms, educational institutes and public buildings, must also be considered. ►

To reduce uncertainties in radon estimates and to facilitate the identification of areas in future for which there are currently no accurate estimates available, data collected by the federal states in accordance with uniform and comparable benchmarks is to be made available, where possible, to the BfS. This data is to be recorded there in a standardised federal database "radon in buildings" (Bundeseinheitliche Datei Radon in Gebäuden – BuRG Datenbank). Current available data and new data to be recorded will be used by the BfS to provide an updated radon estimate. ►

Pursuant to section 121 (1), third sentence of the Radiation Protection Act, the identification of radon prone areas is to be reviewed every ten years. Once the data basis is significantly improved, the radon estimates for Germany are to be updated by the BfS. The estimate results are then to be made available to the federal states. ►

Data collected to designate radon prone areas must be presented in a simple and comprehensible manner to the public. Suitable formats are to be prepared to present the distribution of radon in Germany or each federal state and communicate the consequences of long-term radon exposure

Measure 2.2:

Take further measurements of radon activity concentration in soil gas and of soil gas permeability

Measure 2.3:

Develop uniform measurement strategies and methods for quality-assured determination of radon activity concentration in indoor air

Measure 2.4:

Take further measurements of radon activity concentration in indoor air

Measure 2.5:

Collect data acquired on radon occurrence centrally in the BuRG database of the BfS

Measure 2.6:

Update radon estimates for Germany

Measure 2.7:

Process radon data for public relations work

and available radon data processed. This will reduce the possibility of misinterpreting the data. The presentation of radon activity concentration in a particular area is generally done by selecting suitable physical and statistical parameters which can be visually represented using maps, for example maps of radon activity concentration in soil gas. Here it must be taken into consideration that many factors can influence radon activity concentration in indoor spaces. For instance, the geological character of the subsoil and its permeability determine the level of radon activity concentration in soil gas. The structural condition of the building determines how much radon can seep into it, for example through cracks, splits and pipe passages. The rate of air change, that is the rate at which indoor air is exchanged with outdoor air, depends on the type of use, usage habits and meteorological parameters. ◀

II.3 Measures to prevent or significantly impede radon ingress into habitable rooms in new buildings

Protection against elevated radon activity concentration in indoor air should be taken into account early on in the planning stages of construction projects. Radon ingress from the building foundation must be prevented through appropriate construction measures. If corresponding knowledge is available (see measure 6.2), an alternative building material may be selected to help minimise radon activity concentration in habitable rooms and workplaces caused by the release of radon from building materials. Persons involved in the planning and construction of a building with habitable rooms and workplaces are to acquire the knowledge necessary to prevent radon ingress by means of construction measures and further develop them.

Pursuant to section 123 (1), first sentence, of the Radiation Protection Act, suitable measures are to be taken by those who construct a building with habitable rooms or workplaces to prevent or significantly impede radon ingress from the subsoil. This obligation is deemed fulfilled when moisture protection measures required in line with the generally acknowledged rules of technology and at least one of the measures under section 154 of the Radiation Protection Ordinance are complied with in radon prone areas. This provides parties awarding building contracts with an easy and reliable way to ensure they fulfill their obligation under section 123 (1), first sentence, of the Radiation Protection Act. However, the obligation under section 123 (1), first sentence, of the Radiation Protection Act can be fulfilled in other ways and using other measures. In this case, it must be ensured that these measures are also appropriate to prevent or significantly impede radon ingress from the subsoil.

The German Institute for Standardization (DIN) is currently preparing a standard, DIN SPEC 18117 in line with the procedures laid down for a

so-called “pre-standard”. DIN SPEC is intended to present harmonised technical solutions for construction measures to protect against radon or to determine and elaborate on them.

Outside of these regulations, practical descriptions of construction measures to protect against radon are expedient and can be used by those awarding construction contracts and construction experts in construction planning. To this end, the federal government and the federal states must make information resources and in-depth information available that are regularly updated to reflect the latest state of knowledge. ►

To advance the development of construction measures to protect against radon, studies are to be carried out to review the effectiveness of radon protection in new buildings. To achieve the desired further development of technical measures, radon experts and experts from the fields of construction and ventilation technology will need to work together. ►

Radon protection should be incorporated into the education, further education and training courses provided for building experts, architects, energy consultants and other relevant occupational groups. This will enable these occupational groups in future to properly apply radon protection measures, where necessary, and further develop and optimise them. To this end, nationally coordinated education, further education and training course concepts on radon protection for construction experts should be prepared. ►

Quality assurance in construction projects; certification

Even minor structural defects can lead to radon seeping into buildings, for instance through improperly sealed areas. Methods, measures and processes for radon protection which guarantee the quality assurance of construction measures must therefore be drawn up. Methods and processes are then to be formulated to assess, if necessary, after construction is complete whether radon protection measures have been implemented successfully. There is no public law obligation to test radon activity concentration in indoor spaces as a means of performance evaluation during construction or after construction is complete. ►

Certificates of quality such as quality seals enable those who are not from the field to assess, when buying or occupying a building, whether elevated radon activity concentration can occur in the indoor air. An increased demand for information from home owners and tenants is to be expected. The aim must therefore be to review the possibility of integrating radon protection into existing quality certification. ►

Measure 3.1:

Make more in-depth information available on measures to reduce radon ingress into habitable rooms in new buildings

Measure 3.2:

Analyse effectiveness of construction measures to protect against radon in habitable rooms in new buildings

Measure 3.3:

Develop and implement a nationally coordinated concept for education, further education and training courses on radon protection for experts

Measure 3.4:

Formulate concepts to assess the quality of execution of radon protection measures in new buildings

Measure 3.5:

Integrate radon protection into existing quality certificates for buildings

II.4 Measures to reduce radon activity concentration in the air in existing buildings

Measure 4.1:

Review and, if necessary, implement financial support options for remediation of residential buildings with habitable rooms in which elevated radon activity concentration has been recorded

Measure 4.2:

Develop and evaluate technical possibilities for remediation of existing buildings

Radon protection is aimed at reducing both the radon activity concentration above the reference level and also average radon levels throughout the entire building stock in Germany. The objective is to support the public relations work outlined in section II.1 through a system of incentives and targeted measures and to make concrete information available on construction measures to protect against radon in existing buildings. It is to be reviewed whether radon protection measures will be financially supported and, if applicable, linked to other measures to support building remediation, in particular measures which considerably reduce air change rate. The federal government and federal states will review the possibilities for corresponding programmes. ◀

As with new buildings (see section II.3), coordinated analysis programmes are also to be carried out to review the effectiveness and efficiency of construction measures to protect against radon in existing buildings. Available construction measures must be evaluated and concrete recommendations for measures for the public made available. ◀

Heritage conservation interests shall be respected.

Federal state-specific information and awareness-raising strategies for the remediation of existing residential buildings

Reduction measures are to be implemented as a priority in buildings where radon activity concentration in indoor air exceed the statutory reference levels. In the context of implementing the requirement for optimisation under radiation protection, measures to reduce radon activity concentration can also be useful below the reference level. The necessity and scope of the measures are to be determined on the basis of the radon activity concentration levels in the indoor air, taking into account the conditions of usage, the extent to which the reference level is exceeded, if applicable, and the construction work and financial effort required.

Overall, federal states-specific information and awareness-raising strategies must be designed to reduce radon activity concentration to below the reference level of 300 becquerels per cubic metre through remedial measures to protect against radon, in so far as technically and economically feasible. The implementation of these information and awareness-raising strategies is covered by the measures in section II.1.

Radon in buildings with public access

As with private buildings, elevated radon activity concentration can also occur in buildings with public access. Both the ingress of radon and the distribution of radon, and subsequently radiation exposure, can vary considerably between private buildings and buildings with public access due to the different uses of the buildings.

This can be attributed, for instance to the different sizes and layout of rooms or different airing and heating habits. In addition, buildings with public access are generally only open at certain times, have a large amount of people going through them and may also have workplaces. The measures presented in this action plan include buildings with public access. Measures relevant for such buildings are outlined below.

A nationwide public relations strategy as well as complementary strategies adapted to federal state conditions have to be developed, coordinated and implemented. Public relations work plays a very important role for buildings with public access, especially in sensitive areas such as child care facilities and schools. ►

See measures 1.3 and 1.4

Measurement strategies for radon activity concentration in indoor air have to be drawn up and further measurements taken (measures 2.3 and 2.4). These must take buildings with public access into consideration. The measurement strategies to be developed are to take account of the special requirements of these building types. The strategies must endeavour to harmonise measurements for certain building types. In this way, the aforementioned different usage habits and building structures, for instance of private and public buildings will be taken into account. Furthermore, measurement results of certain building types, for instance with similar building structures and usage habits can be combined and, where applicable, used to derive strategies for remedial measures to protect against radon. ►

See measures 2.3 and 2.4



II.5 Radon in the workplace

Radon protection measures in workplaces are to be implemented using a tiered approach. A measurement obligation must apply firstly, to all workplaces in radon prone areas located on the ground floor or basement level and secondly, to workplaces in fields of work where high radon activity concentration is expected such as mines, drinking water treatment and supply facilities and radon baths (see annex 8 to the Radiation Protection Act). Workplace means any place at which a worker is regularly or repeatedly present during the performance of his or her occupational duties. The objective of the measures is to take account of radon protection at an early stage for new workplaces and for existing workplaces, where high radon concentration has been identified, to take reduction measures and ensure quality assured determination of worker exposure.

Firstly, radon activity concentration measurements are used to identify workplaces where the reference level of 300 becquerels per cubic metre is exceeded. In these workplaces, measures to reduce radon activity concentration are to be implemented as a priority to decrease exposure on a widespread basis and include more than just individual, particularly affected workplaces in these measures. Generally, there is no difference between reduction measures and procedures for measuring radon activity concentration used for workplaces, and those used for habitable rooms. If the radon activity concentration measured exceeds the reference level stipulated for workplaces after reduction measures, the workplace must be registered with the competent authority and the exposure of every worker to radon must be estimated.

In radon prone areas, it is important that the parties responsible for the workplace, the workers and the owners of the commercially used space are informed of the characteristics and risks of radon. Doing so will increase acceptance for the required measures and help ensure that measures to reduce radon activity concentration are also taken into account in the planning of workplaces. Suitable target groups and multipliers must be identified, for example chambers of commerce and work safety experts. Public relations work in this field is to be closely coordinated with public relations work to inform the public, as people in radon prone areas, both as workers and members of the public, may be affected. ◀

See measure 1.1

This information is also aimed at ensuring that measures to impede and reduce radon ingress are already taken into account in the planning stage of construction measures. The corresponding measures take habitable rooms and workplaces into account and are presented in section II.3. ◀

See measures 3.1 to 3.5

In workplaces which fulfill the following criteria, radon activity concentration measurements are to be taken:

1. the room is in a radon prone area,
2. the room is located on the ground floor or basement level and
3. workers are regularly or repeatedly present during the performance of their occupational duties.

Furthermore, measurements are to be taken in workplaces in fields of work for which elevated exposure to radon is expected due to a correlation between the presence of radon and the work carried out. These fields of work are listed in annex 8 to the Radiation Protection Act.

The measurements are to be carried out in line with the generally acknowledged rules of technology and in accordance with the requirements of a recognised body. In order to harmonise approaches, measurement strategies and quality assurance procedures are to be drawn up. ►

See measure 2.3

Where the reference level for workplaces is exceeded, in general, measures to reduce radon activity concentration are to be taken. In this context it should be noted that depending on the type of workplace, different measures may be appropriate and expedient. There are also fields of work in which, for instance for hygiene reasons the reduction of radon activity concentration is not always feasible (for example radon caves, water works). ►

See measure 4.2

Suitable experts are needed to plan, accompany and review reduction measures. They are to be trained and offered further training courses. ►

See measure 3.3

If the reference level for radon activity concentration is still exceeded after a reduction measure, the radon exposure of workers is to be estimated. To this end, provisions for calculating the estimate are required, taking account of working hours and radon activity concentration in particular. Corresponding provisions are to be drawn up. In particular, for workplaces where the equilibrium factor significantly deviates from the level usually expected in habitable rooms, the procedures are to be adapted to the exposure situation to allow for the exposure to radon and radon decay products to be more accurately estimated and measures to be taken. If the estimate indicates that exposure can exceed six millisieverts per calendar year, the body dose of workers is to be determined through measurements. ►

Measure 5.1:

Formulate a procedure to estimate and measure exposure in workplaces

Measure 5.2:

Conduct long-term review of list of fields of work with elevated exposure to radon

Workplaces registered with the competent authority in accordance with Section 129 of the Radiation Protection Act are to be used to draw first conclusions regarding fields of work with elevated exposure to radon. The estimate made is to be verified by means of additional analyses in selected fields of work not listed in annex 8 to the Radiation Protection Act. ◀

Measure 6.1:

Carry out research on radon and protective measures

II.6 Research on radon and protective measures

Further research projects are required to expand on findings and radon protection measures. Such projects may examine the health impacts of radon, construction measures to protect against radon and the area of risk communication. The influence of thoron on human health must also be examined to evaluate the necessity of measures to protect against thoron. Overall, open research questions must be identified and then prioritised as a first step. ◀

Measure 6.2:

Identify building materials which can significantly contribute to elevated radon activity concentration in indoor air

Building materials with significant radon exhalation

Building materials in Germany only account for a very limited share of radon activity concentration in the indoor air of buildings (generally below 10 becquerels per cubic metre, rarely above 20 becquerels per cubic metre of radon activity concentration recorded). However, in individual cases, higher contributions cannot be ruled out, for instance up to 50 becquerels per cubic metre for the use of unfired clay (Federal Office for Radiation Protection [BfS] 2012). Industrial residues are also used in the manufacture of construction products. The influence of these new developments on radon exhalation from construction products should be continuously monitored. ◀

II.7 Precautionary measures regarding radon in drinking water

Protection against radon in the use of water intended for human consumption and extracted from drinking water supply facilities is regulated in the Drinking Water Ordinance (Trinkwasserverordnung [TrinkwV]). The Drinking Water Ordinance lays down parametric values for radioactive material (for example radon-222: 100 becquerels per litre). If these values are exceeded, the competent authority reviews whether the presence constitutes a risk to human health that requires action. In addition, an analysis concept is laid down (Drinking Water Ordinance Annex 3 a Part III) on the conduct, scope and frequency of analysis and on the assessment of parametric values (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety [BMUB] 2017b). Gaseous radon emitted from drinking water accumulates in indoor air. Generally in Germany, only a negligible proportion of radon activity concentration in indoor air in buildings is attributed to radon from drinking water.

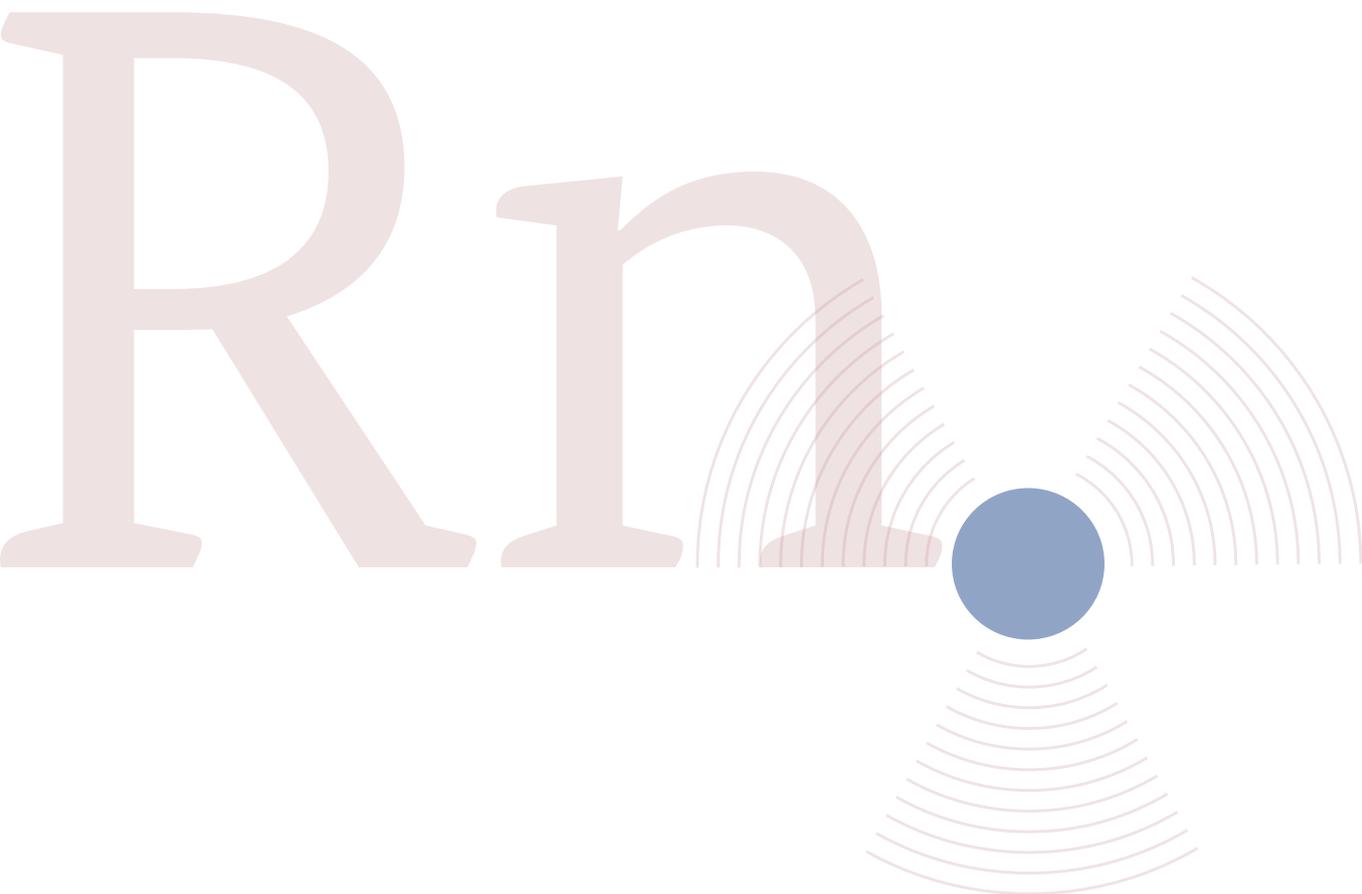
These levels are already recorded in connection with determining the annual average radon activity concentration. There is thus currently no need for further measures to protect against radon in drinking water within the framework of the Radon Action Plan.

II.8 Evaluation of implementation of measures

The implementation of the Radon Action Plan is to be evaluated at appropriate intervals to assess the effectiveness and further development of radon protection in Germany and make amendments if necessary. To this end, the implementation of the measures listed is to be regularly reviewed to ensure radon protection measures are highly efficient and effective. To evaluate the success of individual measures, short and long-term indicators are to be developed with which the effectiveness of the measures can be reviewed. Suitable indicators are then to be collected at appropriate intervals nationwide to facilitate an evaluation of the development of radon protection in Germany. ►

Measure 8.1:

Develop and identify short and long-term indicators to evaluate radon protection measures



Evaluation of the action plan and status of implementation of measures

III

The implementation of measures will be managed by a steering group chaired by the BMU. Results and progress made will be presented by the steering group to the expert committee on radiation protection (FAS) of the federal state committee for nuclear energy. The expert committee on radiation protection will submit comments and suggestions to the steering group. Coordinated findings of work will be forwarded to the competent expert bodies, for instance the expert committee on radiation protection or the federal state working group on environment-related health protection (LAUG).

Experiences, surveys, analyses and evaluations to identify and tackle radon occurrences will be reviewed after ten years and, where necessary, supplemented and updated.

In accordance with section 122 of the Radiation Protection Act, this action plan will be updated at least every ten years by the BMU with the participation of the federal states and taking account of experiences gained. Updating the plan provides an opportunity to address new, unforeseen needs for analysis and, based on this, develop further measures.

References

IV

BfS 2012: Natürliche Radioaktivität in Baumaterialien und die daraus resultierende Strahlenexposition (2012).

BMUB 2017a: Umweltradioaktivität und Strahlenbelastung: Jahresbericht 2015 (2017).

BMUB 2017b: Leitfaden zur Untersuchung und Bewertung von radioaktiven Stoffen im Trinkwasser bei der Umsetzung der Trinkwasserverordnung (2017).

Darby et al., 2005: Radon in homes and risk of lung cancer: collaborative analysis of individual data from 13 European case control studies (2005).

Euratom 2013: 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 (2013).

IAEA 2014: IAEA Safety Standards Series No. GSR Part 3. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (2014).

ICRP 2014: Radiological Protection against Radon Exposure. Ann. ICRP 43(3) (2014).

WHO 2009: WHO Handbook on Indoor Radon (2009).

Annex

Description of measures

Catalogue of measures

Number	Title of the measure	Page
1.	Public relations work	28
1.1	Identify target groups, multipliers and target group-appropriate communication channels to provide information on radon	28
1.2	Prepare resources to support an easier understanding of the health impacts of radon	28
1.3	Develop and implement a nationwide public relations strategy to create basic understanding of radon among the public	29
1.4	Develop federal state-specific public relations strategies which take account of regional radon exposure conditions	29
2.	Survey of radon occurrence and identification and designation of radon prone areas	30
2.1	Develop uniform measurement strategies and measures for quality assurance for measuring radon activity concentration in soil gas and soil gas permeability	30
2.2	Take further measurements of radon activity concentration in soil gas and of soil gas permeability	30
2.3	Develop uniform measurement strategies and methods for quality-assured determination of radon activity concentration in indoor air	31
2.4	Take further measurements of radon activity concentration in indoor air	31
2.5	Collect data acquired on radon occurrence centrally in the BuRG database of the BfS	32

Number	Title of the measure	Page
2.6	Update radon estimates for Germany	32
2.7	Process radon data for public relations work	32
3.	Measures to prevent or significantly impede radon ingress into habitable rooms in new buildings	33
3.1	Make more in-depth information available on measures to reduce radon ingress into habitable rooms in new buildings	33
3.2	Analyse effectiveness of construction measures to protect against radon in habitable rooms in new buildings	33
3.3	Develop and implement a nationally coordinated concept for education, further education and training courses on radon protection for experts	34
3.4	Formulate concepts to assess the quality of execution of radon protection measures in new buildings	34
3.5	Integrate radon protection into existing quality certificates for buildings	35
4.	Measures to reduce radon activity concentration in the air in existing buildings	35
4.1	Review and, if necessary, implement financial support options for remediation of residential buildings with habitable rooms in which elevated radon activity concentration has been recorded	35
4.2	Develop and evaluate technical possibilities for remediation of existing buildings	36
5.	Radon in the workplace	36
5.1	Formulate a procedure to estimate and measure exposure in workplaces	36
5.2	Conduct long-term review of list of fields of work with elevated exposure to radon	37
6.	Research on radon and protective measures	37
6.1	Carry out research on radon and protective measures	37
6.2	Identify building materials which can significantly contribute to elevated radon activity concentration in indoor air	37
7.	Precautionary measures regarding radon in drinking water	38
8.	Evaluation of implementation of measures	38
8.1	Develop and identify short and long-term indicators to evaluate radon protection measures	38

1. Public relations work

Measure 1.1	Identify target groups, multipliers and target group-appropriate communication channels to provide information on radon
Description	Target groups shall be identified for efficient and effective public relations work. They shall be addressed via target group-oriented communication channels. Possible multipliers suitable for reaching relevant target groups and that are held in high regard by the target groups shall be identified and included in the public relations work. Strategies to include multipliers in public relations work shall be developed. Experts, for example from the fields of radiation protection, construction and communication, shall work together on this on an interdisciplinary basis.
Expected result	Identified target groups, multipliers and communication channels
Coordination	BMU
Implementation	Competent authorities of federal states, BfS
Envisaged implementation by/in the period	2019 to 2020

Measure 1.2	Prepare resources to support an easier understanding of the health impacts of radon
Description	The health impacts of long-term exposure to radon shall be presented to the public in a simple and understandable manner. Comparisons may be made with other suitable risks (for instance passive smoking). The goal shall be to harmonise communication with communication in the area of other indoor pollutants.
Expected result	An appropriate concept to present the consequences of radon exposure, which will encourage measurements and, if necessary, protective measures to be taken
Coordination	BMU
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2020



Measure 1.3	Develop and implement a nationwide public relations strategy to create basic understanding of radon among the public
Description	A national public relations strategy on radon shall be developed with the involvement of the federal states, taking account of state-specific strategies, and, if applicable, with the involvement of multipliers and experts. The involvement of stakeholders should be striven for. Relevant events which can boost public visibility, should also be incorporated into the strategy (for example European Radon Day). The implementation of the strategy shall, among other things, lead to coordinated information material as far as possible and directly follow on from the development of the strategy.
Expected result	Nationwide public relations strategy to create basic understanding of radon among the public and to implement this measure
Coordination	BMU
Implementation	BMU, BfS with involvement of competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2020

Measure 1.4	Develop federal state-specific public relations strategies which take account of regional radon exposure conditions
Description	For individual federal states, appropriate public relations strategies shall be developed and implemented to inform the public about radon in a suitable manner. These information and awareness-raising strategies shall also cover the construction of new buildings and protective measures against radon in existing residential buildings, particularly in the context of other construction and modernisation measures.
Expected result	Federal state-specific public relations strategies adapted to local occurrence of radon which are coordinated with the federal government and other federal states
Coordination	Competent authorities of federal states
Implementation	Competent authorities of federal states with participation of federal government
Envisaged implementation by/in the period	2019 to 2020

2. Survey of radon occurrence and identification and designation of radon prone areas

Measure 2.1	Develop uniform measurement strategies and measures for quality assurance for measuring radon activity concentration in soil gas and soil gas permeability
Description	<p>Uniform measurement strategies to measure radon activity concentration in soil gas and soil gas permeability shall be developed which ensure the comparability of measurements to be carried out throughout Germany. The measurement strategies shall be created in the form of handouts or guidelines and, if necessary, measurement instructions. These shall be extended, where possible, to include specific measurement protocols and forms for recording measurements. To facilitate appropriate quality assurance, a strategy and quality assurance process shall be established (for example through measurement comparisons).</p> <p>The measurement strategies shall, as far as possible, be published in a freely accessible format.</p>
Expected result	<ul style="list-style-type: none"> → Measurement strategies to measure radon activity concentration in soil gas and soil gas permeability → Strategy and process to carry out quality assurance for measurements
Coordination	BfS
Implementation	BfS in cooperation with representatives of federal government and federal states and other experts from the field
Envisaged implementation by/in the period	2019 to 2021

Measure 2.2	Take further measurements of radon activity concentration in soil gas and of soil gas permeability
Description	<p>Further measurements of radon activity concentration in soil gas and of soil gas permeability (which can be combined to give the parameter radon potential) shall be carried out using a uniform procedure. The BfS will support the federal states with the proper implementation of the strategies to be carried out to improve the data situation. Important aspects which shall be taken into account are geology, population density, settlement structure and the quality of the building stock. Areas with lower numbers of measurement stations and with estimates of elevated radon occurrence shall be examined as a priority. To better take account of special local geological characteristics and small-scale structures and identify classification errors, larger-scale maps than those used previously shall be used, where possible. The BfS shall provide advisory assistance with the identification of areas for compaction measurements. In addition, the possibility of establishing other methods, particularly for local area designation, shall be reviewed.</p>
Expected result	Improved radon potential data situation to increase local spatial resolution and validate radon estimate for Germany
Coordination	BfS
Implementation	Competent authorities of federal states, BfS
Envisaged implementation by/in the period	2019 to 2028

Measure 2.3	Develop uniform measurement strategies and methods for quality-assured determination of radon activity concentration in indoor air
Description	Uniform measurement strategies shall be developed to measure radon activity concentration in habitable rooms and workplaces. Depending on the different objectives (for example determination of annual average), the strategies shall be published as hand-outs or guidelines and, if necessary, as measurement instructions and in a freely accessible format. In doing so, it shall be reviewed whether it is necessary to consider thoron and different measurement arrangements for different building types (for example one-family house, apartment building, commercial property, warehouse, large building, building with cellar, partially cellared building). Economic aspects shall be taken into consideration in the determination of measuring procedures and quality assurance procedures shall be established for measurements. Measurement strategies already implemented by other countries shall be considered and experiences, particularly regarding indoor air hygiene, shall be taken into account. In the preparation of measurement strategies it shall be reviewed whether projects shall be carried out to develop protocols for quality assured short-term measurements and to increase the accuracy and validity of measurements (for example long-term fluctuations in radon activity concentration and influence of certain meteorological parameters).
Expected result	Measurement strategies and quality assurance procedures for measuring radon activity concentration in habitable rooms and workplaces
Coordination	BMU
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2021

Measure 2.4	Take further measurements of radon activity concentration in indoor air
Description	A greater number of representative measurements in habitable rooms shall be carried out throughout all of Germany. Measurements shall be organised by the BfS, but also by federal states which consider further measurements necessary. Financing options to fund measurements, particularly in habitable rooms, educational institutes and public buildings, shall be considered.
Expected result	Measurements of radon activity concentration in indoor air in Germany
Coordination	BfS
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2028

Measure 2.5	Collect data acquired on radon occurrence centrally in the BuRG database of the BfS
Description	It will be agreed in an administrative agreement between the BMU/BfS and the federal states, that data collected from measurements will be submitted to the BfS to be recorded in the standardised federal database "radon in buildings" (Datei Radon in Gebäuden - BuRG Datenbank). The quality assured data shall be made available to the federal states via the BuRG database.
Expected result	Conclusion of administrative agreement; data on radon occurrence in Germany recorded in BuRG database and available.
Coordination	BfS
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2028

Measure 2.6	Update radon estimates for Germany
Description	When a sufficiently large data set of new measurements is available, the BfS, in coordination with the BMU and the federal states, will calculate a new estimate of radon potential in Germany. The result shall be made available to the federal states. For area designation, the federal government and federal states shall work together and develop a handout with procedural proposals for the federal states to designate areas on the basis of BfS estimates also taking their own data and knowledge into account.
Expected result	Updated radon estimate for Germany
Coordination	BfS
Implementation	BfS
Envisaged implementation by/in the period	2020, repeat if necessary

Measure 2.7	Process radon data for public relations work
Description	Suitable formats for presenting radon distribution in Germany to communicate the risks of radon exposure shall be devised which take adequate account of factors such as geology and building stock and that reduce potential misinterpretations. Uncertainties shall also be appropriately presented.
Expected result	Easily understandable maps of Germany and the federal states to communicate the risks of radon exposure
Coordination	BMU
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2020, repeat if necessary

3. Measures to prevent or significantly impede radon ingress into habitable rooms in new buildings

Measure 3.1	Make more in-depth information available on measures to reduce radon ingress into habitable rooms in new buildings
Description	Practical recommendations for preventative radon protection in new buildings shall be drawn up to facilitate the implementation of legal provisions. Recommendations of the German Institute for Standardisation DIN joint working group NABau/NHRS Radon geschütztes Bauen and other expert bodies shall be taken into consideration. Information on this topic, together with further information on radon, shall be published in a new edition of the German Radon Handbook (Radonhandbuch Deutschland). Different target groups are to be adequately taken into account.
Expected result	More in-depth information and recommendations on radon protection in new buildings
Coordination	BMU
Implementation	Radon protection experts from federal government and federal states and experts from the fields of moisture protection, ventilation and construction
Envisaged implementation by/in the period	2019 to 2020, update if necessary

Measure 3.2	Analyse effectiveness of construction measures to protect against radon in habitable rooms in new buildings
Description	Analysis programmes shall be set up to review, for example, the effectiveness of radon protection in newly constructed buildings. The quality of radon protection in construction shall be further developed. In particular, once the DIN SPEC 18117 has been published, the effectiveness of measures listed there to protect against radon in new buildings shall be evaluated. Further measures shall be identified if required, existing measures shall be further developed and the suitability of new engineering developments shall be analysed. Experiences of other countries shall be evaluated.
Expected result	Estimation of suitability (cost-benefit ratio including possible follow-up costs) and effectiveness of different construction measures for effective protection against radon in new buildings
Coordination	BMU
Implementation	BMU, competent authorities of federal states
Envisaged implementation by/in the period	2020 to 2028

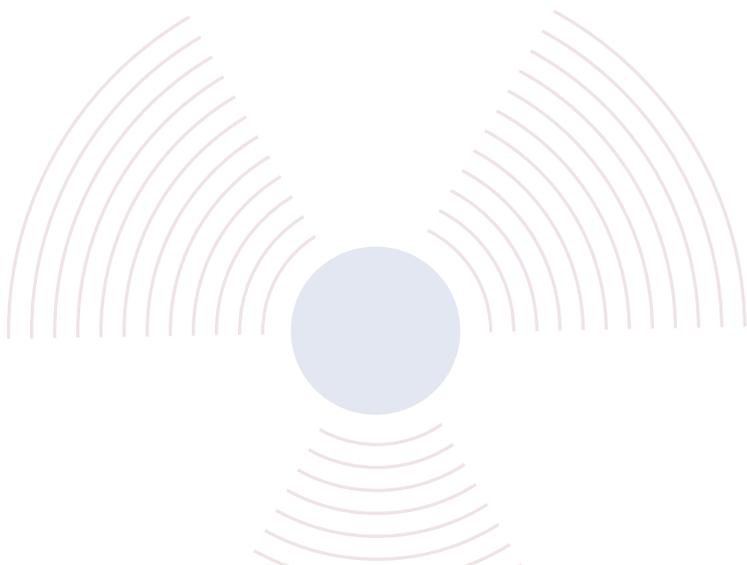
Measure 3.3	Develop and implement a nationally coordinated concept for education, further education and training courses on radon protection for experts
Description	<p>A survey shall be conducted on the available number of education, further education and training courses on radon protection and a collection put together of the content and experiences of these courses. International experience shall also be incorporated.</p> <p>It shall be reviewed how knowledge on radon protection can be integrated into the education, further education and training of experts nationwide (for example construction experts, architects, energy consultants and others).</p> <p>Strategies and evaluation procedures shall be developed and communicated to harmonise radon protection requirements (for example minimum air change rate) and the requirements of other fields.</p> <p>Quality assured implementation of construction and other measures to protect against radon shall be taken into consideration.</p> <p>A common understanding among the federal states regarding education, further education and training programmes shall be reviewed. Existing courses into which radon can be integrated shall be identified. If required, new courses shall also be conceived.</p>
Expected result	A harmonised education, further education and training concept on radon protection for experts from relevant fields
Coordination	BMU
Implementation	BMU, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2020

Measure 3.4	Formulate concepts to assess the quality of execution of radon protection measures in new buildings
Description	<p>Quality assurance concepts shall be developed for protection against radon in new buildings. In particular, concepts shall be drawn up that ensure radon protection is adequately taken into account and can be checked if necessary. There is no public law obligation to test radon activity concentration in indoor spaces as a means of performance evaluation during or after construction.</p> <p>The sustainability of measures shall be considered to facilitate another review of radon activity concentration after a reasonable period of time.</p>
Expected result	Quality assurance concepts for radon protection in new buildings
Coordination	BMU
Implementation	BfS with support of competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2028

Measure 3.5	Integrate radon protection into existing quality certificates for buildings
Description	It shall be reviewed whether quality criteria for radon protection can be developed and integrated into existing quality certificates in other areas. The aim shall be to achieve such integration. The period of time for which the certificates are valid shall also be reviewed if necessary.
Expected result	Concept for quality certificates for buildings with habitable rooms or workplaces that are protected against radon
Coordination	BMU
Implementation	BMU, BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2028

4. Measures to reduce radon activity concentration in the air in existing buildings

Measure 4.1	Review and, if necessary, implement financial support options for remediation of residential buildings with habitable rooms in which elevated radon activity concentration has been recorded
Description	The possibilities and requirements of support programmes for the remediation of residential buildings with elevated radon activity concentration in indoor air, particularly in radon prone areas, shall be reviewed by the federal government and the federal states. It shall also be examined whether synergies can be achieved with other support programmes.
Expected result	Concepts for financial support programmes for the remediation of buildings with elevated radon activity concentration in indoor air
Coordination	BMU
Implementation	BMU, BfS, competent authorities of federal states
Envisaged implementation by/in the period	2019 to 2025



Measure 4.2	Develop and evaluate technical possibilities for remediation of existing buildings
Description	The effectiveness of protective measures for existing buildings with habitable rooms and workplaces shall be reviewed. The quality of construction measures to reduce radon and continued efficacy of measures already implemented to protect against radon shall be further developed. For remedial measures to protect against radon in existing buildings, information material shall be prepared with the involvement of remediation experts and bodies specialised in this field. The time periods and scope of measures which may be implemented, depending on radon activity concentration measured and respective framework conditions, shall be presented. Measures shall also be developed and reviewed to prevent or counteract an increase in radon activity concentration in indoor spaces caused by building alterations that lead to a significant reduction in the rate of ventilation. Through the establishment of a publicly accessible database to collect reduction methods and examples, solutions can be highlighted and experiences with successful remedial measures for radon protection compiled (for example communication/designation of best practices).
Expected result	<ul style="list-style-type: none"> → Evaluations of available reduction measures for existing buildings → Information material and recommendations on measures to protect against radon in existing buildings
Coordination	BMU
Implementation	BfS and other experts from the federal government and federal states from the fields of radon protection, moisture protection, ventilation and construction
Envisaged implementation by/in the period	2019 to 2028

5. Radon in the workplace

Measure 5.1	Formulate a procedure to estimate and measure exposure in workplaces
Description	<p>Guidelines and requirements shall be drawn up to estimate the body dose of workers based on the measurement of radon activity concentration in the air in workplaces, time spent there and other influencing factors. These shall be made accessible to the public.</p> <p>It shall be reviewed whether special requirements are needed for the use of measuring equipment to determine body dose. If necessary, such requirements shall be defined and published.</p>
Expected result	Guidelines for estimating and measuring the body dose of workers
Coordination	BMU
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	By end of 2019

Measure 5.2	Conduct long-term review of list of fields of work with elevated exposure to radon
Description	Using data on registered workplaces, conclusions are to be drawn regarding fields of work with elevated exposure to radon. It is necessary to take account of whether the exposure is elevated due to geological conditions or the field of work. Annex 8 to the Radiation Protection Act is to be reviewed on this basis.
Expected result	Updated list of fields of work with elevated exposure to radon
Coordination	BMU
Implementation	BfS, competent authorities of federal states
Envisaged implementation by/in the period	2022 to 2026

6. Research on radon and protective measures

Measure 6.1	Carry out research on radon and protective measures
Description	Knowledge on radon and on measuring and protective measures shall be advanced through research projects and studies. In addition to radon, the significance of thoron shall also be examined.
Expected result	Further studies on radon to improve the data and information situation
Coordination	BMU
Implementation	BfS
Envisaged implementation by/in the period	2019 to 2028

Measure 6.2	Identify building materials which can significantly contribute to elevated radon activity concentration in indoor air
Description	Building materials of certain types and origins which can significantly contribute to elevated radon activity concentration in indoor air shall be identified. To this end, new developments on the construction products market shall be monitored and radon exhalation measurements taken by radon sampling or in cases of justified suspicion. If necessary, thoron shall also be monitored.
Expected result	List of building materials which can significantly contribute to elevated radon activity concentration in indoor air
Coordination	BMU
Implementation	BfS, Federal Institute for Materials Research and Testing (BAM)
Envisaged implementation by/in the period	2019 to 2028

7. Precautionary measures regarding radon in drinking water

No further measures required, see section II.7

8. Evaluation of implementation of measures

Measure 8.1	Develop and identify short and long-term indicators to evaluate radon protection measures
Description	Short and long-term review criteria to evaluate the success of the measures and targets for protection against radon in Germany envisaged under the radon action plan and radiation protection legislation shall be set out. Review criteria are to be developed in the form of measurable indicators. These indicators shall facilitate a review of target achievement of measures before an update of the radon action plan. Experiences gained in other countries shall be availed of. A suitable selection of these indicators shall be identified.
Expected result	Short and long-term indicators to evaluate the success of measures and targets to protect against radon
Coordination	BMU
Implementation	BMU, BfS
Envisaged implementation by/in the period	by 2028



List of abbreviations

BAM	Federal Institute for Materials Research and Testing
BfS	Federal Office for Radiation Protection
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
Bq	Becquerel
BuRG	Standardised federal database “radon in buildings” (Bundeseinheitliche Datei Radon in Gebäuden)
DIN	German Institute for Standardization
FAS	Expert committee on radiation protection (Fachausschuss Strahlenschutz)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
LAUG	Federal state working group on environment-related health protection (Länderarbeitsgruppe Umweltbezogener Gesundheitsschutz)
m ³	Cubic meter
StrlSchG	Radiation Protection Act
StrlSchV	Radiation Protection Ordinance
TrinkwV	Drinking Water Ordinance
WHO	World Health Organization

