



federal agency for nuclear control

Belgian National Radon Action Plan 2020-2025

This national radon action plan has been drafted by FANC after consultation and with contributions of the stakeholders.

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1. Introduction

Radon is a radioactive gas, odourless, colourless and chemically inert, coming from uranium which is present in soil and rocks. In Belgium, it is found in the underground in varying quantities depending on the geological characteristics. Hence, it can penetrate into the buildings by different openings and accumulate in it, leading to concentrations which can be sometimes really high. Radon irradiates lung tissues, which can lead to lung cancer.

This version brings minor changes (clarifications and corrections) to the January 2020 version.

2. Requirements of the European Directive 2013/59/Euratom

In application of Article 103 of the Directive [2013/59/Euratom](#), Member States shall establish a national action plan addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water.

In Belgium, policy and regulations on ionising radiation are a federal competence, with the competent authority being the Federal Agency for Nuclear Control ([FANC](#)). Following the European and international recommendations, FANC has set up a national radon action plan that is in application since 2009. On the FANC website, a specific dossier has been developed on this subject ([link](#)). The plan considers the activities and strategies (for surveys, communication, building protection, remediation, mapping, and management) to develop and put in practice each year, in order to achieve the general goal (reduce the exposure to radon of the population and workers). This document completes the existing radon action plan with additional content following ANNEX XVIII of the EU BSS Directive 2013/59/Euratom. The action plan consists on the one hand of relatively continuous items, such as strategy, definition of working fields and technical details, completed by variable items such as annual actions, being updated and published in the annual radon action plan each year.

The existing regulatory framework is essentially published in the FANC [Law](#) from 1994, the [Royal Decree](#) of 20 July 2001, the [FANC Decree](#) of 30 November 2015 and the procedures and guides published on the FANC web-site ([link](#)). In order to implement the scientific findings published after the 1990's ([WHO, 2009](#), UNSCEAR 2009, ICRP 60, 65, 103, 115), the international Basic Safety Standards ([IAEA BSS](#)), and the European Directive [2013/59/Euratom](#), the existing regulations are in the process of being updated. The current action plan uses the definitions, reference levels and dose values fixed in the EU BSS, while some of the above mentioned national documents are in the process of revision. The revision will be accomplished within a couple of months after the publication of the revised Royal Decree.

3. Objectives of the radon action plan

3.1. Introduction

Since 1990, a considerable effort has been made to determine the distribution of radon in dwellings, public buildings and workplaces in Belgium (early academic surveys in the late 1980 and early nineties (Vanmarcke et al., 1988; Poffijn and Vanmarcke, 1990)), SPRI (Protection Service against Ionizing Radiations) campaigns between 1995 – 2000 (Zhu et al. 1998)). These studies have demonstrated that there are specific radon risk areas on the Belgian territory.

Since 2005, detailed campaigns, in cooperation with different provinces, regions or municipalities have been organized in the areas most affected by radon as well as throughout the country (annual national radon actions since 2013). These campaigns are ongoing and are an important input for further remedial actions, statistics and mapping, and preventive initiatives.

3.2. Long-term objectives

- General protection of new buildings with a design level of 100 Bq/m³ (*cf.* §6.2.1). This will reduce the collective dose and will lead to a substantial reduction of lung cancer incidence.
- Stand-still of the exposure situation in low-risk areas. Avoid the increase of the radon concentration by a decrease in ventilation (low energy construction) or an increase in radium content in building materials.
- Aim for a radon distribution in the most affected areas to approach that of the low-risk areas. This will be assured, in addition to the above mentioned measures, by protective measures against radon ingress in new buildings and mitigation of existing buildings with high radon levels.

3.3. Short-term objectives

- Training of building professionals (for construction techniques and building material sector).
- Training of technical and administrative stakeholders.
- General prevention in the most affected areas, to reduce the population's exposure to radon (to reduce the collective dose).
- Trace and remediate all buildings with a radon concentration above and around the reference level (to reduce the individual dose). The number of affected buildings is estimated at around ~ 36,000 dwellings and ~ 2,000 workplaces in Belgium.

3.4. Graded approach

In order to achieve the objectives of the radon action plan, a graded approach is followed focussed initially on the areas with the highest exposure, and gradually extended to areas and situations that are less exposed. The actions are focussing on the following main components:

- Regulations (fixing reference levels, defining radon management in dwellings and workplaces, guaranteeing external collaborations, etc.).
- Communication (raising public awareness and proactivity of stakeholders (publications, brochures, website, training, road-shows, etc.).
- Measurements and mitigation (different types of campaigns, data management, mapping, inspections, remediation).

3.5. Reviewing of the national radon action plan

In order to evaluate the effectiveness and impact of the national radon action plan, indicators will be defined that quantify the effect of preventive- and remedial measures, inspections and measurement campaigns, such as:

- Annual number of measurements performed in dwellings and workplaces,
- Evolution of the statistics of the performed measurements,
- Annual number of remedial actions reported,
- Effectiveness of the remedial actions reported,
- Findings of the annual inspection programme (cf. §6.1.4),
- Survey (every 2 years) of the effectiveness of preventive measures in new buildings.

This information will allow a detailed review of the national radon action plan every 5 years.

4. Strategy for conducting surveys (measurements)

Different types of surveys are organised both on a regular basis (annually) and ad hoc in specific situations when identified and considered needed.

- In order to provide to the Belgian population the possibility to perform low-cost and easy accessible indoor radon measurements, a web-platform has been developed (www.actioradon.be).
- Indoor radon measurements for workplaces are available through the dedicated web-platform www.radonatwork.be.
- At specific requests or after having identified a specific situation, detailed measurement campaigns can be organised in collaboration with local authorities, municipalities, professional organisations, neighbouring countries, *etc.*
- Indoor radon measurement campaigns can be complemented by soil sampling and/or soil-gas measurement campaigns.

Procedures, background information and guidelines are published on the FANC website www.fanc.fgov.be, both for professionals (workplaces) and the public.

5. Classification of the territory in radon classes (mapping)

FANC has published in the Official Gazette a decree ([FANC decree of 30 November 2015](#)) that classifies the territory in terms of the probability to exceed the radon reference level in buildings. This map is also available on the FANC website ([link](#)) and in a specific interactive web mapping environment ([link](#)). The 5 classes which are defined according to the reference level are:

- Class 0: less than 1% of the houses are below the reference level.
- Class 1a: between 1 and 2% of the houses are below the reference level.
- Class 1b: between 2 and 5% of the houses are below the reference level.
- Class 2a: between 5 and 10% of the houses are below the reference level.
- Class 2b: more than 10% of the houses are below the reference level.

Municipalities where the probability to exceed the reference level of 300 Bq/m³ is above 5% are considered as radon prone areas (RPA).

In order to optimize the homogeneity of the statistical data, the classification of the Belgian's municipalities is made based on the radon's concentrations measures (in Bq/m³) that are done in the houses, in a living area on the ground floor. These measurements are done in the context of the different measurements campaigns organised by FANC.

For the specific purpose of radon prevention and protective measures in new to be built buildings, a specific radon map has been developed representing on a 1x1 km grid the probability to exceed within this square kilometre the reference level of 300 Bq/m³. This map allows local authorities and builders to check the building site or surroundings in order to identify the specific preventive measures to be applied. This map is available through the different radon web-sites and through a dedicated interactive web mapping application ([link](#)).

6. Regulation of radon risk management

6.1. Radon risk management in workplaces

FANC has published since 2012 specific regulations and guidelines for radon measurements in workplaces ([link](#)). Based on the experience from radon measurements and inspections in workplaces in the period 2001-2010, the guidelines serve to the concerned workplaces (employers) as a tool to commit to the existing regulations.

The workplaces which have to measure the concentrations of radon and to introduce a notification dossier are the ones situated on a municipality classified in class 2 and enumerated on §6.1.3.

6.1.1. Reference level

The reference level is defined as the annual average radon concentration above which it is judged inappropriate to allow exposures to occur as a result of that exposure situation, even though it is not a limit that may not be exceeded. The reference level for radon in workplaces (and in dwellings) has been fixed at 300 Bq/m³. When reference level is exceeded, a notification has to be submitted to FANC, in application of articles 4, 9 and 20 of the radiation protection regulation (RD 2001). For the workplaces concerned, correctives measures have to be implemented, unless a risk analysis confirms that the maximum exposure level of 600 kBq/h/m³ is not exceeded.

6.1.2. Dose conversion coefficients

In order to estimate the (annual) exposure of the population to radon and the related risk, and for managing the health risks related to radon exposure in workplaces, it is necessary to calculate the time integrated exposure and to estimate annual doses resulting from radon exposure. In the EU BSS 2013/59/Euratom, this principle is specified in article 35.2, stating the necessity to manage radon in workplaces as a planned exposure (practices), if the exposure of the workers is liable to exceed 6 mSv/y. In order to make this assessment, doses received from radon have to be calculated, based on conversion factors from volumetric radon concentration to time integrated exposure and dose. These dose conversion factors are fixed by international organisations and committees such as the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the National Academy of Sciences Biological Effects of Ionizing Radiation (BEIR) and the International Commission on Radiological Protection (ICRP). Belgium (FANC) uses the dose conversion factors as published in [ICRP 137](#). In short, the dose coefficient in most indoor exposure situations corresponds to $6.7 \cdot 10^{-6}$ mSv (Bq h m⁻³)⁻¹. This results for workplaces (with a yearly working time of 2000h and equilibrium factor $F=0.4^1$) in 1 mSv = 80Bq/m³ (and 6 mSv corresponds to ~450 Bq/m³). Once ICRP or Euratom Article 31

¹ The equilibrium factor F is a measure of the disequilibrium which exists between the radon gas and its progeny due to ventilation and deposit on surfaces.

Expert Group will publish more definitive conversion factors, these will be used for dose estimation and risk calculations.

6.1.3. Identification of workplaces

Radon measurements have to be carried out in specific workplaces in the municipalities classified in Class 2 (more than 5% of probability to exceed the reference level of 300 Bq/m³). The measurement protocol and the declaration of the measurement results to the competent authority (FANC) are specified in guideline documentation on the website ([link](#)) and in a specific document ([link](#)). The employer, responsible for the measurements in the workplaces can order the radon detectors directly through the website www.radonatwork.be, or through the list of radon measurement service providers registered at FANC and published on a list on the FANC website ([link](#)).

In the first place, the following priority workplaces have to measure and report radon concentrations:

- Educational institutes, day-care centres, medical centres
- Public buildings (post, provinces, municipalities, police, libraries)
- Underground workplaces (galleries and caves open to the public)
- Water treatment facilities

6.1.4. Corrective measures

If the reference level for a specific declaration is exceeded, the employer is required to carry out corrective measures, either directly by reducing the radon concentration (interventions in terms of ventilation in basements or crawl-spaces, sub-soil depressurisation, mechanical controlled ventilation systems, etc.), or through an intermediate step by carrying out a risk analysis calculating the different exposure scenarios of the employees (Articles 4 and 9 of RD 2001). This requires generally a measurement campaign in the workplace premises by active and continuous radon monitors. Guidelines are published on the FANC website ([link](#)).

6.1.5. Assignment of responsibilities

FANC is responsible on the Belgian territory for the protection of the workers to the effects of ionising radiation (RD 2001, Art. 4, 9, 20.3). Therefore FANC is the competent authority for everything related to radon measurements, follow-up, declarations and inspections in workplaces. FANC assures the implementation of the radon measurements in workplaces, the declaration of the results and the remedial and corrective measures related to the possible high exposures and sets out responsibilities by the following means:

- Regular meetings with local employers such as municipalities, regional authorities, provinces, trade unions, services for prevention and protection at work.
- Information campaigns through road-shows, professional fairs and exposition events, mailings, bilateral contacts.
- A yearly inspection programme setting out the strategy and procedures to inspect compliance to the regulations of the targeted workplaces.

Guidance for the different involved parties and stakeholders is provided on the level of information about the regulatory system ([link](#)), the procedures for measurements ([link](#)) the procedures for declaration/notification of measurement results ([link](#)), measurement service providers ([link](#)), and technical assistance for implementing corrective measures ([link](#)). The different information is also available through dedicated brochures available through local stakeholders (medical, preventive, local authorities, etc.) and through the FANC web site ([link](#)).

6.2. Radon risk management in dwellings

6.2.1. Reference level

The reference level for radon concentrations in dwellings is based on the information available from different surveys on the territory (*cf.* §5.1.1). It is important to note that it serves as a tool for optimisation of the protection of the public (and the workers). The reference level for dwellings (such as workplaces) is 300 Bq/m³. Optimisation has to be applied above as well as below the reference level, up to levels of exposure that have to be as low as reasonably achievable (As Low As Reasonably Achievable - ALARA), with the target level of 100 Bq/m³ (Fig. 1). Above the reference level, 600 Bq/m³ is defined as the intervention level, above which corrective measures have to be put in place as soon as possible. Above the reference level, FANC provides detailed information on remedial actions as well as free control tests (detectors) to evaluate the efficiency after remediation.

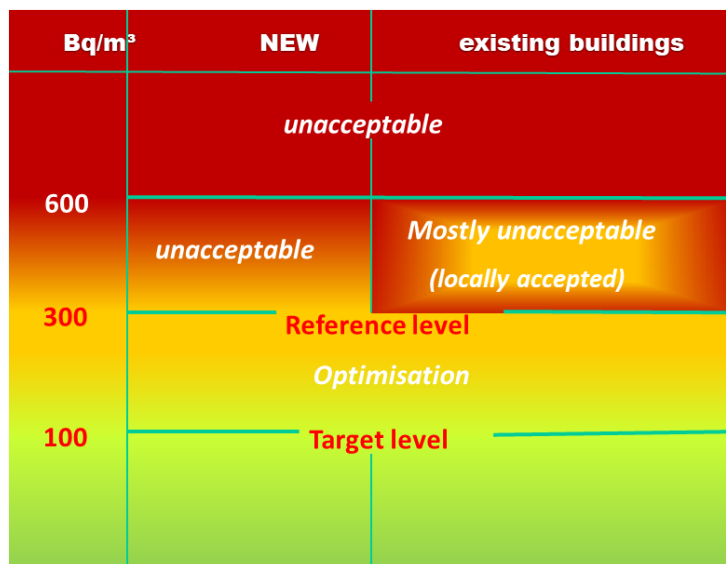


Fig. 1 The use of the reference level as a tool for optimisation of the radiation protection.

For new buildings, the target level is the target-level which no new building should in principle exceed, provided that the correct preventive measures have been implemented.

On base of the available data from radon surveys, the following distribution of radon concentration in Belgium has been identified:

Table 1. Average radon exposure of the Belgian population (population data for 2010). AM: arithmetic mean, MED: median, GM: geometric mean, GSD: geometric standard deviation. Values are in Bq/m³. RPA: radon prone areas. % gives the percentage of single family houses above the indicated radon concentration (in Bq/m³).

	Population	dwellings	AM	MED	GM	GSD	% >100	% >200	% >300	% >400	% >800
Belgium	10584534	3742000	57	44	46	1.7	10.0	2.1	0.9	0.6	0.2
Wallonia	3435879	1325000	84	60	75	1.7	26.0	4.5	2.6	1.6	0.4
Flanders	6117440	2191000	44	37	36	1.2	3.2	0.1	0.05	0.0	0.0
Brussels	1031215	226000	44	37	36	1.2	4.0	0.1	0.1	0.0	0.0
RPA	376568	130000	220	127	137	1.9	43.0	33.0	17.0	13.0	4.3

Based on this information, the number of buildings affected by the different radon concentration levels can be estimated as follows:

Table 2. Estimate of the number of dwellings (single family houses) in the different categories of radon exposure (Bq/m³).

	dwellings	>100	>200	>300	>400	>800
Belgium	3742000	360000	84000	36000	21000	5600
Wallonia	1325000	280000	79000	35000	21000	5600
Flanders	2191000	70000	some	some	0	0
Brussels	226000	9000	5000	some	0	0
Radon prone areas	130000	56000	43000	22000	17000	5500

The number of dwellings exceeding the level of 300 Bq/m³ is about 36000. The number of affected workplaces is estimated at the order of magnitude of about 3600. These data have been published by the Superior Health Council in 2017. The radon reference level is a tool for optimisation, and specifically in workplaces it is used to steer the graded approach of the radiation protection. The legal level of radon exposure, as defined in Article 20.3 of the radiation protection regulations (RD 2001) is

600 kBq/m³ per year. This means that a worker who is exposed during 2000 hours per year (approximative full-time employment) to more than 300 Bq/m³ (reference level of radon concentration) will exceed the exposure limit and is submitted to notification and corrective measures (Art. 9 RD 2001).

6.2.2. Assignment of responsibilities

FANC is the competent authority for the protection of the population and the environment against ionizing radiation in the event of exposure to radon (Art. 1 of RD 2001). One of its tasks is to control the dose due to radon received by the population (Art. 70) and to reduce these doses, if necessary (Art. 20.2 and 72bis). Therefore, FANC has the mission to assure the role of the coordinating authority and to help organize activities aimed at applying the regulations, complying to the obligations and raising awareness of the actors involved in radon. Therefore FANC strives at close collaboration with the following actors: the federal and regional public services Employment, Health, Housing and Environment, the provinces, the municipalities, professional organizations (in the medical field, prevention services, construction professional organisations, etc.), academic and institutional (universities, Scientific and Technical Center for Construction - CSTC, research centres, Belgian Nuclear Research Centre - SCK-CEN, National Institute of Radioelements - IRE, etc.), foreign and international organizations (European Union - EU, Dutch Authority for Nuclear Safety and Radiation Protection - ANVS, German Federal Office for Radiation Protection - BfS, French Nuclear Safety Authority - ASN, French Radiation Protection and Nuclear Safety Institute - IRSN, Heads of the European Radiological protection Competent authorities - HERCA, European Radon Association - ERA, International Radiation Protection Association - IRPA, Joint Research Centre - JRC, etc.) and the general public.

The coordinative role of FANC is important in order to assure a centralized coordination of all radon actions to ensure uniformity of approaches, messages, measures and interventions throughout the territory. In addition, this ensures compliance of all actions with the recommendations and current conclusions of international bodies in the field of radiation protection. Centralized coordination is the only way for good management and the statistical and scientific analysis of all data relating to radon (screening measures, control measures, remediation, cartography, epidemiology, etc.). The Directive 2013/59/Euratom imposes member states to develop a national action plan (Art. 103). The reference level for radon cannot exceed 300 Bq/m³.

Guidance for the different involved parties and stakeholders is provided on the level of information about the regulatory system ([link](#)), the procedures for measurements ([link](#)), measurement service providers ([link](#)), and technical assistance for implementing corrective measures ([link](#)). The different information is also available through dedicated brochures available through local stakeholders (medical, preventive, local authorities, etc.) and through the FANC web site ([link](#)).

6.2.3. Remediation of existing buildings

In the framework of the annual radon measurement campaigns (www.actionradon.be), house-owners are stimulated to carry out remedial actions by the following approach:

- Proposal of remedial actions for measurements around the reference level, through brochures ([link](#)) and the publication of a list of trained radon professionals ([link](#)).
- Proposal of radon inspection and diagnostic services by FANC in collaboration with local authorities for all measurements exceeding 600 Bq/m³ (cf. §6.2.1).
- Proposal of free control measures after remedial actions (cf. §6.2.1).
- Financial intervention by the regional government for remedial actions ([link](#)).

Above the reference level, in the case of existing buildings, sometimes it will be impossible or too difficult to reasonably reduce the radon concentration below the reference level. In such cases, evaluated on a case-by-case basis, exposure situations can be locally accepted (Fig. 1). Finally, for communication purposes, the reference level can be represented on a continuous scale ranging from low risk to high risk (Fig. 2).

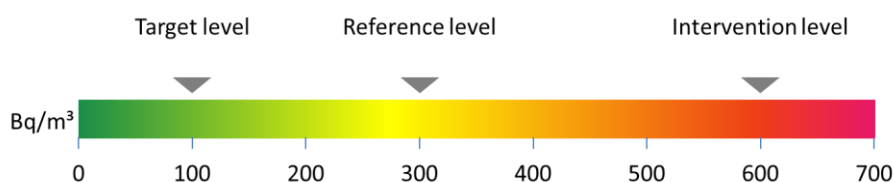


Fig. 2. Radon Reference level on a continuous scale from low health risk to high health risk.

6.2.4. Prevention in new buildings

The protection of new buildings against radon ingress is very important in order to achieve the general long term objectives of the radon action plan. In order to prevent radon ingress in new dwellings, awareness campaigns are organised to inform the public on the radon risk and on the protective measure to take during the construction of the building. Besides informing the public by [publications](#), and [interactive mapping](#) applications, training of building professionals and local governmental administrations is essential. Including regulations on radon protection in the building codes, a regional competence, is essential in order to implement radon protection in a structural and sustainable way. Concertation with the regional authorities on the implementation of these protective measures in the building codes is essential in attaining the goals. The regional construction code of the Walloon Region impose the description of the radon protective measures by the responsible architect in the building permit (Case 13 in Annex 4 of the Building Code [link](#)).

6.3. Radon from building materials and from drinking water

Radon coming from building materials is managed through the regulatory framework for radioactivity in building materials ([Royal Decree](#)). The Activity Concentration Index, limiting Ra-226 (300 Bq/kg), Th-232 (200 Bq/kg) and K-40 (3000 Bq/kg) in any building material guarantees low levels (around 100 Bq/m³ or lower) of indoor radon in normal ventilation conditions. Limiting the radon concentration in drinking water (limit of 100 Bq/l, [2013/51/Euratom](#)) will guarantee low levels (around 100 Bq/m³ or lower) on indoor radon in normal ventilation conditions.

7. Raising public awareness, communication and stimulating proactivity

7.1. Communication Plan

A communication plan has been defined by FANC in 2014, aiming at efficiently inform the public, workers, employers and building professionals and to communicate essential messages stimulating the stakeholders to measure, mitigate and protect themselves, their families, their employees. Communication with specific professional target groups such as lung-cancer specialists, general practitioners, architects, building research and administration, etc. aims at progressively inform and stimulate protective/preventive activities.

7.2. Interaction with the indoor air quality programme

The overall management and requirements for Indoor Air Quality includes radon as a pollutant and cancerogenic agent and is treated in the document Superior Health Council 2017, report published in 2017 ([link](#)).

7.3. Public Awareness

Increasing awareness of the risks and solutions related to radon exposure to the public, the workers, the employers and the specific professionals is a basic task and specific actions on this field are defined annually in the section actions and activities.

7.4. Training programmes

Details on training courses of professionals such as architects, builders, medics, local authorities, specific students etc. is defined annually in the section actions and activities.

7.4.1. Building professionals

Specific material has been developed in collaboration with the Belgian Building Research Institute ([BBRI](#)) and training is provided in collaboration between [FANC](#), [BBRI](#) and the Walloon Building Confederation ([CCW](#)). The building professionals who followed specific training on radon and who are active in the radon field are listed on the FANC website ([link](#)).

7.4.2. Administrations

Local administrations (regions, provinces, municipalities, school administrations, prevention advisors, labour inspection, labour medicine, etc.) are being trained and informed during specific workshops, meetings or conferences, defined annually in the annual Radon Action Plan.

8. Data management

In order to evaluate, monitor and map the exposure of the Belgian population, all the measurement results, mitigation and protection efficiency have to be documented, managed and archived in an appropriate and efficient database management system. Currently, data are managed in an ArcGIS geodatabase allowing for regularly updated radon maps and statistics. The radon action plan strives to the development and implementation of a performant dbms that links all the available information concerning radon in Belgium and that will allow a thorough and detailed analysis and evaluation of the efficiency of the Belgian radon Action Plan.

9. Conclusions

The following actions are planned and published annually in order to achieve the objectives of this action plan:

- Organisation of training courses
- Information and measurement campaigns in dwellings and workplaces
- Surveying radon in water and building materials

In practice, this implies :

- Reinforced collaboration with the Walloon Government concerning the Walloon regional action plan and focussing on the demands of BSS Art. 103 regarding new building protection
- Training courses of building professionals in collaboration with CCW and BBRI
- Organisation of the national Radon Action in October (www.actionradon.be), stimulating the public to measure and mitigate, with press releases and road shows
- Participation to construction exposition fairs for raising awareness on radon
- Measurement campaign in workplaces (www.radonatwork.be)
- Round table session for labour medicals and prevention advisors
- Detailing and updating the radon mapping in high risk areas based on new measurements in sub-soil information (geology, karst, ...)
- Evaluation of radon in water and building materials, measurement campaigns
- Continuous evaluation of changes in building techniques (low energy building, ventilation,...) on the indoor radon concentrations
- Finalisation of the regulatory documents : Royal Decree, FANC Decree, FANC procedures, recommendations and Specifications
- Continuous international collaboration with the neighbouring countries (FR, LU, GE, NL) for mapping, harmonisation and public awareness, with international organisations (JRC, ERA), and in the frame of the EU Project LIFE RESPIRE (LIFE16 ENV/IT/000553).

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11. Glossary

ALARA: As Low As Reasonably Achievable

ANVS: Dutch Authority for Nuclear Safety and Radiation

ASN: French Nuclear Safety Authority

BEIR: National Academy of Sciences Biological Effects of Ionizing Radiation

BfS: German Federal Office for Radiation Protection

CCW: Walloon Building Confederation

CSTC: Scientific and Technical Center for Construction

ERA: European Radon Association

FANC: Federal Agency for Nuclear Control

HERCA: Heads of the European Radiological protection Competent authorities

ICRP: International Commission on Radiological Protection

IRE: National Institute of Radioelements

IRPA: International Radiation Protection Association

IRSN: French Radiation Protection and Nuclear Safety Institute

JRC: Joint Research Center

RPA: Radon Prone Areas

SCK CEN: Belgian Nuclear Research Centre

SPRI: Protection Service against Ionizing Radiations

EU: European Union

UNSCEAR: United Nations Scientific Committee on the Effects of Atomic Radiation