

NATIONAL ACTION PLAN 2020-2024

FOR MANAGEMENT OF THE RADON RISK

This report was drafted by the French nuclear safety regulator (ASN) in collaboration with the members of the national action plan oversight committee:

The Minister responsible for the environment
The Minister responsible for housing
The Minister responsible for labour
The Minister responsible for health
The regional health agencies
Regional Directorate for Enterprises, Competition,
Consumer Affairs, Labour and Employment
Institute for Radiation Protection and Nuclear Safety
The scientific and technical centre for the building trades
The study and assessment centres for risks,
the environment, mobility and development
Associations involved in the “radon” topic
The national union of measurement professionals.

For the French population, exposure to radon is the leading source of exposure to ionising radiation of natural origin. Radon is the second cause of lung cancer, behind smoking, and thus represents a public health issue in France. The quantitative evaluation of the health impact, updated in 2018 on the basis of the most recent data, confirmed the data previously published in 2007: about 3,000 deaths from lung cancer per year would appear to be attributable to radon in indoor air in France, or about 10% of deaths from lung cancer¹. For equal levels of exposure to radon, the risk is far higher in smokers, which explains the fact that three quarters of the deaths from cancer that can be attributed to radon reportedly occur in smokers. However, radon, an indoor air pollutant, remains largely unknown to the general public.

The national radon risk management strategy is built on two main pillars: the regulatory system and the performance of priority actions. It requires coordination on the part of the various actors involved in implementing it. Since 2005, successive national action plans for management of the radon risk have addressed this need for coordinated action and the production of common tools which can be used by all the stakeholders concerned.

Governance of the plan is the responsibility of the various administrations in charge of the regulated sectors: the Ministry responsible for the Environment with respect to housing, the Ministry responsible for Labour with respect to workplaces and the Ministry responsible for Health with respect to buildings open to the public. The French Nuclear Safety Authority (ASN) acts as the technical secretary for the oversight committees. Other entities play an active role in the performance of the actions: national experts, including the French Institute for Radiation Protection and Nuclear Safety (IRSN), regional players, radon activity concentration monitoring professionals and associations active in this field.

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1 Ajrouche R. *et al*, Quantitative health impact of indoor radon in France, Radiation and Environmental, Biophysics (2018) 57:205–214.

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The broad outlines of the PAR 4

1- A plan targeting three areas

The fourth edition of the Action Plan to address risks from radon exposure (PAR 4) follows on from the previous plan, with the same three areas, but in a different context owing to implementation of the regulations resulting from the transposition of Council Directive 2013/59/Euratom. However, if virtually all of the actions of the third plan have been completed, the efforts made need to be continued on certain points:

- the actors concerned by the new regulatory provisions must be informed and assisted with their implementation,
- public awareness of the radon risk needs to be improved,
- improved understanding of the exposure of the population must be sought,
- evaluation of the effectiveness of preventive measures in new buildings and post construction remedial measures must be continued.

The PAR 4 is broken down into 13 actions, split into three areas:

Area 1: Implement an information and awareness-raising strategy

The health issues surrounding radon require that awareness-raising and information measures be continued with all stakeholders (regional authorities, employers, building professionals, health professionals, teachers, etc.) and the general public, both nationally and locally. Local measures for integrated management of the radon risk in dwellings must be promoted and supported. These actions also fall within a regulatory framework which, for dwellings, is supplemented by public information measures, notably for buyers and tenants. Correct imple-

mentation of these new regulatory provisions by the stakeholders concerned is one of the priority goals of the PAR 4.

Area 2: Continue to improve knowledge

The 2018 publication of a new map at the municipal level, based on 3 radon potential zones, enabled a graded approach to radon risk management to be implemented. This map however needs to be improved so that greater account is taken of certain particular geological factors that could facilitate radon transfer to buildings (karst). The operational implementation of the information system incorporating all the radon monitoring results, as well as the consolidation and centralisation of the existing measures, would appear to be essential in improving our understanding of the exposure of the population. On this point, the PAR 4 also aims to update knowledge of population exposure in France, by organising the collection of measurement data.

Area 3: Greater consideration of management of the radon risk in buildings

The building professions organisations are becoming increasingly aware of the potential health risks from radon. In order to help their members improve their level of expertise, they recently developed training courses dealing with methods to prevent and reduce concentration levels and various media to address the needs. A list has been made of these numerous tools in French. Lastly, a guide intended for professionals and private individuals will draw up prevention recommendations for new constructions and remedial measures in existing buildings. The progress made in understanding the effectiveness of construction standards in reducing indoor radon concentrations needs to be consolidated.

2- Summary table of actions per area

Action	Title
Area 1: Information and awareness-raising about the radon risk and the regulations	
1	Public information and awareness about the radon risk. Promotion of and support for preventive measures regarding the radon risk.
	Objectives 1. Support local actions through national actions to facilitate the distribution of information. 2. Whenever possible, include local actions within the broader framework of indoor air quality and thermal retrofit measures, jointly with action 5.
2	Public information and awareness about the radon risk, notably with re-spect to smokers. Raising awareness of health professionals with respect to the radon risk.
	Objectives 1. Via the health professionals, improve the general population's understanding of the radon risk, notably in zones 3, in order to encourage voluntary screening and promote health prevention measures. 2. Inform smokers exposed to radon and help them to stop smoking, including by raising awareness among general practitioners and occupational physicians.

Action	Title
3	<p>Information and support with implementing the regulations concerning radon for buildings open to the public.</p> <p>Objectives</p> <ol style="list-style-type: none"> 1. Inform the owners or, if so specified in an agreement, the operators of buildings open to the public concerned by management of the radon risk, in order to facilitate correct application of the regulations, by developing media appropriate to their needs. Whenever possible, this information shall include the various types of financial aid available. 2. Identify any problems with application of the regulations, including with the provisions of the Labour Code, because the building open to the public is also a workplace. 3. Disseminate specific information to the public received in buildings open to the public and exposed to situations exceeding the reference levels.
4	<p>Information and support with implementing the regulations concerning radon in the workplace.</p> <p>Objectives</p> <ol style="list-style-type: none"> 1. Inform the employers, risk prevention specialists and occupational health services, in order to facilitate application of the regulations by developing media appropriate to their needs. 2. Set up technical or financial support for employers implementing radon risk mitigation actions, notably with the Retirement and occupational health insurance funds for very small enterprises. 3. Monitor application of the regulations in the field and identify any problems with application of the regulations.
5	<p>Promote and support local integrated actions to manage the radon risk in dwellings, in conjunction with measures to improve indoor air quality in dwellings.</p> <p>Objectives</p> <ol style="list-style-type: none"> 1. Gain a better understanding of exposure of the general population to radon. 2. Contribute to raising general public awareness of the radon risk 3. Facilitate information exchanges and feedback from local actions, in order to update the Methodology Guide published in 2018.

Area 2: Improving knowledge

6	<p>Evaluation of the effect of various public radon policies on the health of the population</p> <p>Objective</p> <p>Evaluate the effect of various radon risk prevention options in terms of the health risk. This action will assist the public authorities with managing the radon risk (communication, information, regulation, incentives, etc.).</p>
7	<p>Definition of organisational methods for collecting radon monitoring data, in order to evaluate exposure of the population</p> <p>Objectives</p> <ol style="list-style-type: none"> 1. Update information on the population's exposure to radon and eventually evaluate the effectiveness of the steps taken to manage the radon risks; 2. Target local monitoring campaigns on areas where the data are considered to be insufficient, jointly with action 5; 3. Improve communication with decision-makers and the general public in order to raise awareness of the radon risk in buildings.
8	<p>Provide the results of radon monitoring campaigns in dwellings, workplaces and buildings open to the public.</p> <p>Objective</p> <p>Improve information and the understanding of the local radon risk among the general population and employers</p>
9	<p>Study of geological factors influencing radon levels.</p> <p>Objective</p> <p>Study the conditions for updating the radon map and, on the basis of geological criteria, identify the areas liable to be exposed to radon levels warranting particular vigilance.</p>
10	<p>Conduct a forward-looking study to identify building materials and products liable to emit significant levels of radon</p> <p>Objective</p> <p>Produce a list of building materials and products giving off the highest levels of radon.</p>

Action	Title
Area 3: Radon and buildings	
	Building on, exchanging and disseminating good practices for works in existing buildings, including radon concentration reduction works.
	Objectives
	<ul style="list-style-type: none"> • Dwellings: Continue to build on local and national information in order to target the most effective protection solutions, disseminate them and better identify the competent professionals.
11	<ul style="list-style-type: none"> • Training and skills: <ol style="list-style-type: none"> 1. In a working document, formally set out the technical points for particular attention and the good practices identified, in order to draw up an information guide for construction professionals and project owners; 2. Help professional federations to take greater account of the radon problem in their training tools; 3. Help professional federations to better identify their skills in the field of radon concentration reduction works.
	Building on, exchanging and disseminating good practices for radon concentration reduction works in buildings open to the public.
	Objectives
	<ul style="list-style-type: none"> • Buildings open to the public: Build on local and national information in order to target the most effective protection solutions, disseminate them and better identify the competent professionals.
12	<ul style="list-style-type: none"> • Training and skills: <ol style="list-style-type: none"> 1. Draft an information guide for construction professionals and project owners, identifying the technical points for particular attention and the good practices in a working document; 2. Help professional federations and the managers of public and private buildings open to the public to take greater account of the radon problem in their training tools; 3. Help professional federations to better identify their skills in the field of radon concentration reduction works.
	Prevention of the radon risk in new dwellings.
13	<ul style="list-style-type: none"> • Objective Measure the level of radon in new dwellings.

Appendix Plan strategy and indicators

1. Strategy adopted for management of the radon risk

1.1 New map based on soil radon exhalation potential

Management of the radon risk, in dwellings, in the workplace and in buildings open to the public, takes account of the radon potential in the underlying soil, which is one of the three main factors influencing the radon concentration levels measured in buildings.

The new map² published in 2018 divides the country into three radon potential zones, defined according to the radon exhalation capacity of the soil: low potential (zone 1), low potential but with particular geological factors that could facilitate the transfer of radon to buildings (zone 2) and significant potential (zone 3). Overseas France has been included in the map.

The breakdown of municipalities per zone is accessible on the IRSN website (www.irsn.fr).



1.2 The regulatory context

The regulations relative to management of the radon risk, put in place in the early 2000s for certain buildings open to the public, were extended to certain workplaces in 2008. In 2015, the radon parameter was introduced into the health checks on water intended for human consumption and then, in 2016, into indoor air quality policy. Finally, since 1 July 2018, radon was also introduced into the natural hazards prevention policy, with the obligation of informing the population, notably via information of buyers and tenants of real estate in the zones with the highest radon potential (zone 3).

Greater account is now taken of the health risk, with an average reference level set at 300 Bq/m³ per year for indoor air in all types of buildings: housing, workplaces and buildings open to the public. This reference level is defined as being that above which exposure of persons is considered to be inappropriate.

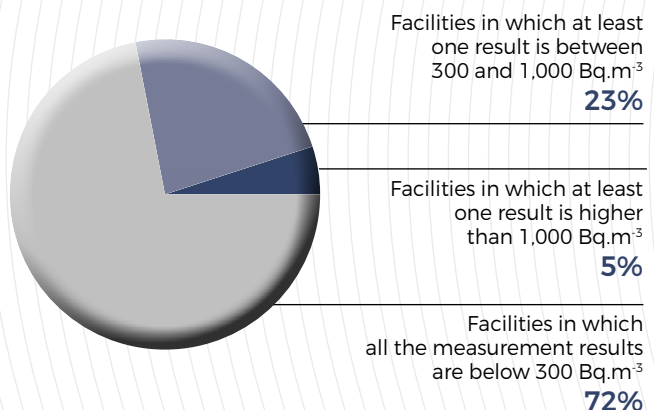
1.2.1 Improved radon management in buildings open to the public

Since 2004, in certain buildings open to the public, the managers are required to monitor radon exposure and to act according to the radon activity concentration levels measured in the indoor air. In 2018, additions were made to the management methods, notably including an improvement in prevention, by incorporating into the system those facilities open to children under 6 years of age, along with an obligation to inform the public by posting the measurement results.

The radon activity concentration measurements are taken by organisations approved by ASN, in compliance with the regulatory requirements (compliance with standards and time of year). In 2020, 102 organisations had been approved. They are listed on the website www.asn.fr.

Results of measurements taken in buildings open to the public

Breakdown of radon concentrations in buildings open to the public and measured between 2015 and the end of 2018 (measurements made by organisations approved by ASN in 4,487 buildings registered in the SISE-ERP database)



The type of action to be taken if the reference level of 300 Bq/m³ is exceeded is graded according to the measurement results³: simple corrective actions for radon concentration measurements between 300 and 1,000 Bq/m³, expert assessment and works if the corrective actions do not enable the reference level to be reached, or if the measurement results are equal to 1,000 Bq/m³ or higher.

² Order of 27 June 2018 delimiting the radon potential zones on French territory.

³ Order of 26 February 2019 relative to the methods for managing radon in certain buildings open to the public and dissemination of information to the people frequenting these buildings.

1.2.2 Reinforcement of regulation in the workplace

The regulations concerning worker protection from exposure to radon were introduced in 2008. They only concerned certain specific workplaces, primarily in basements, where the radon levels can be high. With the new regulatory approach applicable since 2018, resulting from the transposition of Directive 2013/59/Euratom and the incorporation of this hazard into the risk evaluation approach based on the general prevention principles, all employers are now required to examine the potential risk of radon in their workplace.

The evaluation approach for this risk shall first of all be based on documentary data, notably the mapping of the radon potential zones and the presence of workplaces in basements or on ground floors. It can also be based on measurements already taken, in particular if the workplace is also a building open to the public subject to this specific regulation, or on known measurements taken in facilities or companies nearby. When the employer or its risk prevention specialist has any doubt as to whether the reference level could be exceeded in the workplace, they can carry out radon monitoring themselves or have it carried out. This screening shall be performed using radon detectors that can be obtained from suppliers over the Internet⁴. The detectors shall remain in place for at least 2 months, taking account of the specific nature of the workplace, notably whether the premises are particularly favourable to a build-up of radon, or whether there are particular working conditions. Monitoring recommendation were thus published in a guide⁵ to help the employer or its risk prevention specialist in this self-monitoring process.

If the results show that the reference level is exceeded, the employer shall take steps to reduce the radon activity concentration. If these actions prove to be ineffective, it shall identify and signpost the hazard in the premises, in the form of possible “radon zones”. If necessary, depending on worker exposure, it shall adopt reinforced radiation protection measures, although with a few relaxations, given that the situation is one of existing exposure linked to the presence of geogenic radon and not an intentional exposure situation involving the presence of ionising radiation sources that can be controlled as part of their intentional use.

1.2.3 Information and recommendations for dwellings

Since 2016, radon has been considered an indoor air pollutant.

2018 represented a significant step forward for the general population, when an obligation to inform buyers

and tenants of the radon risk was introduced. Vendors and landlords of real estate, of whatever type, located in municipalities with a level 3 radon potential are required to inform the buyers or tenants of this potential risk.

The population is also informed of this risk, as part of the major hazard prevention programme, in radon potential zones of levels 2 and 3, via documents that can be consulted in the office of the Prefect or in the town hall.

The regulations do not stipulate radon monitoring in the indoor air of dwellings. It is therefore up to each homeowner or tenant to obtain information and to conduct monitoring if they consider that their dwellings is liable to exceed the reference level. It should however be noted that the public authorities recommend that such monitoring be carried out for properties located in zone 3. The “Information for buyers and tenants regarding the radon risk” information sheet, available from the www.georisques.gouv.fr website, contains advice for installing radon monitoring detectors and recommendations for reducing the radon concentration in dwellings, depending on the results obtained.

In addition, the Ministry of Health published health recommendations to be distributed to the population by the local stakeholders in order to prevent exposure to radon and the risks associated with this exposure⁶. The message contains an explanation of the effects of radon and the steps to be taken according to the concentration measured. Any overshoot of the action level of 1,000 Bq/m⁻³ requires expert assessment and work to reduce the radon level. A specific recommendation is issued for smokers and former smokers.

1.2.4 Waters intended for human consumption

With regard to water, significant radon activity concentrations can be found in certain geological contexts. In the current state of knowledge, the health risk as a result of ingesting water containing radon is invoked on the basis of theoretical dosimetry considerations. The dosimetry estimations available would appear to indicate that the health risk linked to the ingestion of radon is slight.

In France, the regulations provide for health monitoring of the quality of waters intended for human consumption⁷. Since the early 2000s, health monitoring includes measurement and verification of radiological parameters (total alpha activity, total residual beta activity and tritium activity). Council Directive 2013/51/Euratom of 22 October 2013, transposed into national law at the end of 2015, introduced radon as a surveillance parameter for the radiological quality of waters intended for human consumption. A parametric value of 100 Bq/L was introduced and procedures for managing situa-

⁴ The list of detector suppliers is available on the websites www.asn.fr and www.irsn.fr.

⁵ Practical Guide “Radon risk prevention” September 2020.

⁶ Order of 20 February 2019 relating to health information and recommendations to be sent out to the population in order to prevent the effects of exposure to radon in buildings.

⁷ Water supplied by a mains distribution network, bottled spring waters and waters made drinkable by treatment.

tions potentially exceeding this value were defined⁸. The implementation of health monitoring began on 1 January 2019.

1.3 Local actions to raise awareness of the radon risk in dwellings and factors influencing indoor radon concentrations in dwellings

Monitoring in dwellings is voluntary, so the Ministry of Health offers local stakeholders free detectors to encourage the deployment of local campaigns.

A methodology kit⁹ was published in February 2018 to assist with the deployment of local initiatives. Since it was sent out, an increase in the number of local campaigns has been observed.

Several targeted actions or local awareness-raising, screening and risk reduction support initiatives are thus implemented every year by the regional health agencies, together with the local authorities and/or associations. During the 34 actions carried out since 2000, more than 9,000 detectors have been distributed and analysed free of charge.

The results, combining the measurements of the indoor radon concentration with housing descriptions, give a clearer picture of the exposure of the population in these regions, and analysis of these data has identified factors influencing the indoor radon concentration. In addition to the soil's radon exhalation potential, the type of foundations, the construction material, the construction period, the number of storeys inhabited, the location of the detector, window renovations and the type of ventilation^{10 11} all have a clear influence. These analyses will be continued, building on new data in order to supplement these initial results.

These actions are producing positive results, because the participants are taking measurements with the detectors offered and are improving air renewal in their dwelling. However, a number of factors (cost, lack of financial aid, etc.), can create obstacles to the work aiming to reduce the indoor radon concentration.

This feedback shows the need to continue with awareness-raising measures (see action 4). The IRSN barometer of risk perception and the regional health-environ-

ment barometers indicate that the health risk related to radon is one of the least well-known of the environmental risks¹². This level of awareness is however better in regions where communication actions have been conducted with the general public.

1.4 Updating of knowledge about exposure to domestic radon

The first radon monitoring campaigns in buildings started in the early 1980s and continued until the beginning of the millennium. They led to a total of 12,641 measurements being taken around France. The results evaluated the average radon concentration in buildings at 68 Bq/m⁻³, weighted by the population density for the entire country, with considerable disparities from one region to another, within a given region, and from one building to another¹³.

In order to update knowledge about exposure to domestic radon among the population and the study of health effects, the way in which monitoring results in the home are collected is being examined. This could more particularly provide data about the consequences of changes to the housing stock under the effect of rules for construction and for the retrofitting of older dwellings, and help fill in the areas not covered by the first campaigns (see action 7).

1.5 Development of radon information systems

The regulations provide for the centralisation of the various radon monitoring results.

The monitoring results obtained in buildings open to the public are transmitted to successive databases by organisations approved by ASN, in order to help the regional health agencies manage a number of existing hazards, including radon. As this tool has become obsolete, a new and simpler information system will soon be available.

With regard to water, the Ministry of Health has also set up an information system specifically for the organised storage of health information on water. Radon concentrations have been included in this as of 2019. The data made available to the public notably correspond to the water samples taken as part of the health monitoring programme.

8 Information notice DGS/EA4/2018/92 of 4 April 2018 concerning health monitoring and management of health risks linked to the presence of radon in waters intended for human consumption.

9 https://solidarites-sante.gouv.fr/IMG/pdf/guide_radon_fevrier_2018.pdf

10 Le Ponner E., Collignan B., Ledunois B., Mandin C. Déterminants des concentrations intérieures en radon dans les logements français. Exploitation des données collectées dans plus de 6 000 maisons. [Factors determining indoor radon concentrations in French homes. Analysis of data collected from more than 6,000 houses]. *Environ Risque Sante* 2019 ; 18 : 33-40.

11 Collignan B., Le Ponner E., Mandin C. Relationships between indoor radon concentrations, thermal retrofit and dwelling characteristics. *Journal of Environmental Radioactivity* 165 (2016).

12 For example, the IRSN 2019 barometer measuring the perception of radon risks in 2018 indicates that among those questioned, 21% consider that radon represents a low risk, 31% an average risk and 28% a high risk. The proportion of "don't knows" fell between 1997 and 2008, but has remained on the whole stable since 2008 (20% in 2018).

13 Details of this study can be found on the IRSN website: <https://www.IRSN.fr/FR/connaissances/Environnement/expertises-radioactivite-naturelle/radon/Pages/4-Sommes-nous-tous-exposes.aspx#.XoYFe8ZOLg->

Regulatory changes in 2018 also added the centralisation of the results of the passive detector analyses by IRSN. The accredited organisations which analyse these detectors will submit data to the new database annually (see action 8). It will be accessible to the administrations in 2021 and then later on to the public, as an additional contribution to the information they receive.

1.6 Implementation of prevention methods in new constructions and radon reduction methods in existing constructions

1.6.1 Partial data on the effectiveness of current construction standards on the radon level

The national regulations in force (thermal regulation RT 2012¹⁴ and, in the near future, environmental regulation RE 2021), apply to new-build home for which the building permit was submitted after 1 January 2013.

For energy performance reasons, particular attention is given to the airtightness of the building's envelope in the requirements of the RT 2012. By reducing unwanted air ingress, the impermeability of the ground/building interface constitutes a potential barrier against rising radon. The first results show that the average concentration in "low consumption building" constructions, or RT 2012, situated in zone 3 is usually lower than the reference level of 300 Bq/m⁻³. This effect has yet to be confirmed. Data is also lacking with regard to the consequences on the radon level of structural ageing over time. This is why the monitoring of the indoor radon concentration of new-build dwellings will continue (see action 13) and research is aiming to identify the potential areas with particularly high radon concentrations (see action 9). This could lead to the drafting of additional recommendations, which could be graded according to the characteristics of the building.

1.6.2 More detailed data on good practices in prevention and reduction of high indoor radon concentration.

The effectiveness of the various radon prevention techniques in new-build constructions is now well-known. Most of the countries concerned by the radon risk have adopted similar requirements or recommendations.

In French municipalities located in a level 3 radon potential zone, the Building Industry Scientific and Technical Centre advises building an airtight slab, with the possible addition of tightness products (anti-radon membrane) depending on its composition. Block-outs connected to an air-permeable under-layer (bed of gravel of a type emitting little radon) below the slab will allow active soil depressurisation to be carried out if needed. During the first year of occupation of the construction, the indoor radon concentration shall be measured. If the results exceed the reference level, sub-slab depres-

surisation could then be easily implemented by adding an extraction fan.

In existing buildings, the reduction methods to be applied are graded according to the concentration measured and the characteristics of the building in question: simple corrective measures may initially suffice when the concentration only slightly exceeds the reference level of 300 Bq/m⁻³, whereas more complex and more costly works could be needed for higher concentrations. An expert assessment of the building will be able to identify the causes of the presence of radon, based on possible additional measurements, and recommend the most appropriate technique on a case by case basis. French and foreign operating experience feedback and studies on the efficiency of the various reduction techniques are now available. The results of measurements before and after concentration reduction works in dwellings in France are also contributing to this (see actions 11 and 12).

Energy efficiency retrofitting is worth particularly close attention, because indoor air quality and radon must be taken into account. It has been seen on numerous occasions that the work done to improve energy efficiency is not always accompanied by measures to ensure sufficient indoor air renewal. In this case, the effects are potentially harmful, because the radon then becomes trapped indoors and its concentration can rise significantly. Concrete lessons must be learned from this observation in terms of the training of building professionals.

On the basis of the knowledge which has been constantly added to over time, good practices in both prevention in new constructions and reduction in existing constructions have been identified. Their dissemination now needs to be improved so that they can be implemented as broadly as possible.

1.6.3 Training of building professionals

When a high indoor radon concentration is discovered in an existing building, two particularly important steps are to be taken:

- expert assessment of the building, which corresponds to a methodical inspection of it and its immediate environment. This requires real expertise in order to identify the factors favourable to the build-up of radon inside a given building and to recommend the concentration reduction methods most appropriate for the situation;
- correct performance of the concentration reduction methods.

¹⁴ Decree 2010-1269 of 26 October 2010 concerning the thermal characteristics and energy performance for constructions and order of 26 October 2010 concerning the thermal characteristics and energy performance requirements for new buildings and new parts of buildings.

The PAR 3 identified the information and training tools that had been created to meet the needs of building professionals. In addition, the extent to which the radon risk is taken into account in the initial and continuous training of building professionals was also determined. Today, this shows that there is a lower level of expertise in the building trades than among those who have taken more advanced training (such as architects), where the question of indoor air quality is considered.

Owing to the numerous mandatory training courses required to obtain energy efficiency retrofit accreditation, the building trades are clearly devoting little time to the other training courses. This is why face-to-face training is relatively unattractive, while remote training is enjoying greater success.

In addition, in order to overcome the problem of identifying trained professionals, a number of avenues are to be explored. Initiatives could come from the professional organisations in order to set up a system of accreditations issued by the professional federations to those companies who so wish, so as to recognise their experience in dealing with the radon risk.

It is important to note that awareness-raising should not be restricted solely to zones with a significant radon potential. The reference level is liable to be exceeded in all zones, although to a lesser extent for a municipality in zone 1 than for one in zone 3. The quantitative evaluation of the health impact published in 2018¹⁵ thus draws attention to the fact that “in order to reduce the total number of lung cancer deaths attributable to indoor radon, the reduction of the average of radon concentrations is more effective than focusing only on those people with very high radon concentration, who are of course at the highest individual risk”. Although training the building professionals in the radon problem appears to be a priority in zones with a significant radon potential, it should nonetheless be extended to cover the entire country.

2. Objectives and indicators

A system of specific indicators has been put into place to evaluate the effectiveness of the national strategy implemented under the national action plan. They were chosen for their pertinence and the available data enabling them to be monitored. Measuring the health impact via the change in the number of radon-induced lung cancers can only be evaluated over the long term. Similarly, data on the average indoor radon concentration in dwellings, workplaces and buildings open to the public, reflecting the exposure of the population, are only available on a long-term basis. This requires the determination of intermediate indicators allowing indirect evaluation of the reduction in exposure. For the time being, the aim is therefore to monitor the implementation of the regulations per sector: general public, workplaces and buildings open to the public. These indicators will ultimately be monitored over the long-term (after PAR 4).

For the general public:

- 1- Number of local radon information operations
- 2- Number of dwellings screened during local radon information operations
- 3- Perception of the radon risk among the French population.

For workplaces:

- 4- Number of workplaces with a result $> 300 \text{ Bq/m}^3$ after concentration reduction works
- 5- Number of workers who receive radon exposure individual dosimetry monitoring
- 6- Number of workers who exceeded 20 mSv effective dose over 12 consecutive months
- 7- Number of radiation protection advisers trained for radon

For buildings open to the public:

- 8- Number of buildings open to the public: screened, exceeding the reference level of 300 Bq/m^3 and exceeding the threshold of $1,000 \text{ Bq/m}^3$
- 9- Number of buildings in which work has been carried out
- 10- Number of buildings in which additional measurements have been carried out as part of an assessment process

The PAR 4 will aim to monitor these indicators on a yearly basis.



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