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D9.91 - Report on venues, challenges, opportunities and recommendations for stakeholder engagement in relation to indoor radon exposure

Lead Authors: Catrinel Turcanu (SCK•CEN), Christiane Pözl-Viol (Bfs), Catherine Fallon (ULG), Tanja Perko (SCK•CEN), Marie-Claire Cantone (UMil), Nadja Zeleznik (EIMV)

Reviewer(s): Christiane Pözl-Viol (Bfs)
and
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Abstract

Radon in buildings poses a significant health risk, being one of the most important causes of lung cancer deaths worldwide. Actions to reduce indoor radon have been considered by many EU Member States, and several information campaigns have been conducted to increase radon awareness and trigger actions for radon measurement and remediation. However, increased awareness does not always lead to action. Stakeholder engagement may contribute to addressing this value-action gap, as it has been shown to stimulate systematic information processing and help people make long-term behavioral changes. The revised Basic Safety Directive opens opportunities for higher levels of participation of radon stakeholders, including local actors and affected publics.

This report summarised findings from case studies of stakeholder engagement in practice in relation to exposures to indoor radon, carried out in ENGAGE WP2. The case studies covered communication and management of intervention in the case of a school with a high radon exposure level in Belgium; the implementation of the national radon action plan in Slovenia, with focus on requirements and practices for communication and stakeholder engagement; the role of stakeholders in radon risk and prevention in Italy; and a cross national analysis of radon websites from national and local authorities in eight European Member States, from a stakeholder engagement perspective. Additionally, main findings are presented from a round table on stakeholder engagement in relation to radon exposures, held during the 3rd European Radiation Protection Week on October 2nd, 2018.

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1. Introduction

The ENGAGE project, funded under the H2020 CONCERT, aims at *ENhancinG stAkeholder participation in the GovernancE of radiological risks* [1]. It is a two-year project that started on November 20th, 2017, and which seeks to identify and address key challenges and opportunities for stakeholder engagement in relation to medical use of ionising radiation, post-accident exposures and exposure to indoor radon. In all these situations, stakeholder engagement is a key issue for improving the governance of radiological risks and the radiation protection of the exposed individuals.

The ENGAGE project aims are:

- a. to assess why, when and how stakeholders engage in radiation protection;
- b. to develop novel approaches to analysing stakeholder interaction and engagement, and provide guidance to meet the challenges and opportunities identified in response to (a);
- c. to investigate the processes for enhancing radiation protection culture and their role in facilitating stakeholder engagement, and develop guidelines for building radiation protection culture; and
- d. to build a joint knowledge base for stakeholder engagement in radiation protection.

The ENGAGE project is organized in four main work packages (WPs) coordinated by the management WP, which interact to achieve the objectives as presented on the Figure 1.

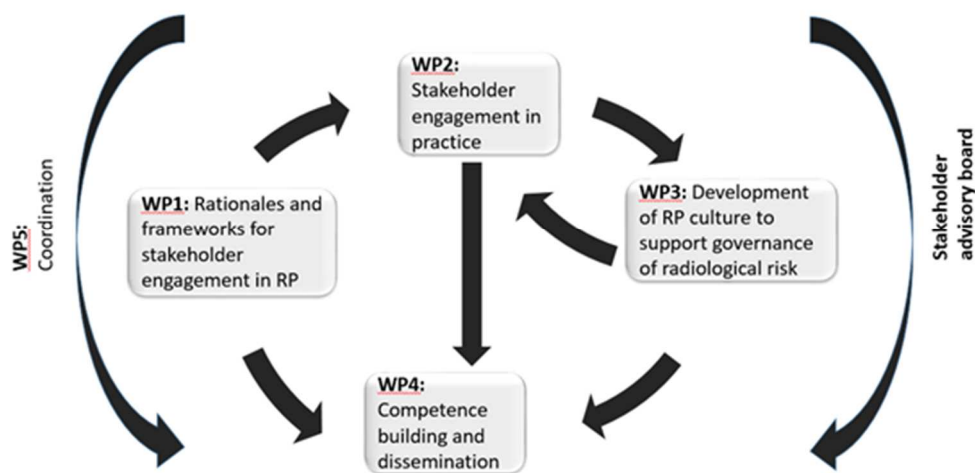


Fig. 1 Interaction between ENGAGE work packages

ENGAGE WP 2 on “Stakeholder engagement in practice” investigates how are legal requirements, guidelines and recommendations for stakeholder engagement implemented in practice. Specifically, it analyses how radiation protection communities respond to the expectations and demands for stakeholder engagement, and what kind of engagements practice, forms and instruments can be found in radiation protection fields, with or without reference to existing requirements.

For this purpose, WP2 is informed by results obtained in WP1 “Rationales and frameworks for stakeholder engagement in radiation protection”, in which the rationales for stakeholder engagement in radiation protection and the related legal or contextual drivers are clarified (how is stakeholder engagement envisaged, who is involved and for what purpose?). The results of WP1 were published in Deliverable 9.85 “Rationales and frameworks for stakeholder engagement in radiation protection in the medical field (Part 1), nuclear emergency and recovery preparedness and response (Part 2) and

indoor radon exposure (Part 3)” and Deliverable D9.86 “Report on stakeholder engagement in radiation protection: transversal issues and specifics of different exposure situations”.

The expected outcomes of ENGAGE WP2 are:

- 1) An evaluation of the impact of past or ongoing participatory activities in radiation protection decision making processes.
- 2) A comparative analysis of stakeholder engagement practice, identifying broader lessons that can be learned, as well as what is specific to each field and why.

WP2 activities were structured along several tasks.

First step of Task 2.1 was to develop the “Methodology for analysing stakeholder engagement in practice”, which provided the framework for analysing ENGAGE cases studies. Guiding research questions for analysing stakeholder engagement in practice were developed. The list of questions is described in section 2 of this report.

Second step within Task 2.1 was a review of selected academic literature, radiation protection research projects connected to stakeholder engagement, current stakeholder engagement practice within radiation protection platforms, as well as past experiences of stakeholder engagement in the three exposure situations and, beyond that, international experiences in stakeholder engagement in radiation protection and connected fields. This review was published in ENGAGE “D9.82 – Report on key challenges, best practices and recommendations for stakeholder engagement.” Based on this review, the initial list of research questions formulated for WP2 was enriched (see section2)

In Tasks 2.2, 2.3 and 2.4, a deeper analysis was carried out on the role of stakeholder engagement in practice in the three exposure situations considered in ENGAGE, based on the guiding research questions: i) medical exposure to ionising radiation, ii) emergency and recovery preparedness and response, and iii) exposure to indoor radon. Current or recent practices, challenges and triggering factors for engagement were studied specifically by means of case studies for each of these exposure contexts.

The aim of this report is to describe objectives and results of the case studies carried out with respect to exposure to indoor radon. The report focusses on the detailed description summarized findings of each case study carried out (section 3). A first comparative conclusion is provided (section 4).

A deeper comparative assessment regarding the findings of the case studies in the three exposure situations will be carried out in the “Final report of the ENGAGE project” (D9.94, due End of November 2019), which will also contain the final recommendations.

2. Stakeholder Engagement in Practice -Aim and Methodology of Case Studies

At the outset of the ENGAGE project, the research for WP2 started from the hypothesis that while stakeholder engagement and informed decision-making are nowadays recognized as essential factors for an effective governance of radiological risk, the practical implementation of policy and legal requirements for stakeholder engagement is confronted with multiple challenges. We must therefore understand better why, when and how stakeholders are engaged in radiation protection. This understanding is necessary to facilitate the development of guidelines and a knowledge base for a more robust stakeholder engagement in radiation protection.

ENGAGE defines stakeholders as: actors (individuals or groups, institutional and non-institutional) with a tangible or intangible (yet to be shaped or discerned) interest in the radiation exposure situation and

the related radiation protection issues, directly affecting decisions, or affected by the formulation and resolution of a problem or challenge. In this perspective, stakeholders are constructed in interaction with actors, issues, contexts. Various publics are also (potential) stakeholders.

While the overarching question in ENGAGE WP1 was *“What are radiation protection (RP) communities being asked to do? That is, what “external” pressures, mandates, demands, and/or expectations have emerged in public venues commending the engagement of stakeholders (including wider publics) in RP?,*

in WP2 we analysed *“What are RP communities doing?”*

- *That is, how are RP communities responding to these pressures, mandates, demands, or expectations and how does this show in practice (e.g. specific cases)?*
- *Which (other) real or potential forms and instruments of stakeholder engagement and public participation can be observed in RP practice, showing no reference to existing requirements?*

More information on how these research questions have been created can be looked up in section 2 of “D9.82 – Report on key challenges, best practices and recommendations for stakeholder engagement.”

In order to operationalise the overarching questions of WP2, these were further explicated in the following derived questions:

- a) What levels of awareness about external prescriptions of stakeholder engagement in radiation protection do researchers and practitioners reveal?
- b) How do researchers and practitioners understand and practice stakeholder engagement (at individual and institutional level)?
- c) What were the rationales for stakeholder engagement, the final objectives? Has there been a critical evaluation of the attainment of objectives and of the impact of stakeholder engagement? Have there been any guided improvement activities?
- d) What forms of acceptance, resistance, denial, or alteration of engagement do you observe or encounter? And how do these forms change over time?
- e) What are radiation protection actors and communities doing that may de facto count as stakeholder engagement (but are not necessarily labelled that way)?
- f) Are there any alignments/misalignments between case practice, on the one hand, and external conceptions and prescriptions, on the other, and if so why? Which challenges and opportunities do you encounter for stakeholder engagement in your specific case?
- g) What else have you found or should we be asking?

The guiding questions a) - g) have informed the analysis reported in D9.82. Following that literature review the following research questions h) – o) were added:

- h) What are the benefits of implementing stakeholder engagement processes (in the situation studied)?
- i) What are the lessons learned for the establishment of efficient stakeholder engagement processes?
- j) Can you identify in official documentation or discourses, or in secondary sources, any references to a “participatory turn” for your field or case? If so, please document and indicate how this turn is understood, why and when it came about.

- k) Can you identify in official documentation or discourses, or in secondary sources, any mention (explicit or implicit) of a shift away from expert-based or technocratic decision making to more inclusive, open, democratic, participatory decision making? If so, please document and motivate, and indicate why and when this shift came about.
- l) Is dealing with emotions one aim of engagement in relation to medical exposure to ionising radiation? And which kind of emotions play a central role?
- m) How can goals and ideals about patient centred communication in radiology be implemented into day-to-day academic and private practice?
- n) How to accelerate the process of bringing together the different disciplines which are necessary to start a stakeholder process in a certain radiation protection field?
- o) How to raise awareness of the need to engage among radiation protection researchers?

Further information on how the guiding research questions were applied are described in each case study description.

The subsequent section summarises the case studies carried out with respect to exposure to indoor radon will be described. In general, the selection of case studies was aimed at covering a broad range of participation practices, stakeholders, and settings. The methods used included desktop research, interviews and observations. Further details are provided in the case study descriptions. Additionally, a separate section summarises the main findings from a round table on stakeholder engagement in relation to radon exposures, held during the 3rd European Radiation Protection Week on October 2nd, 2018.

3. Case Studies

Radon in buildings poses a significant health risk, being one of the most important causes of lung cancer deaths worldwide (WHO, 2009). Actions to reduce indoor radon have been considered by many EU Member States, and several information campaigns have been conducted to increase radon awareness and trigger actions for radon measurement and remediation.

However, increased awareness does not always lead to action and behavioural change: although people living in high radon areas know that radon is bad for their health, they are often not concerned about living in a house with high radon concentration and/or do not undertake radon measurement and remediation actions, even when these actions are subsidized.

Stakeholder engagement may contribute to addressing this value-action gap, as it has been shown to stimulate systematic information processing and help people make long-term behavioral changes.

The revised Basic Safety Directive opens opportunities for higher levels of participation of radon stakeholders, including local actors and affected publics. Specifically, the revised BSS stipulates that the radon action plans which have to be developed by each Member State should include a “*Strategy for communication to increase public awareness and inform local decision makers, employers and employees of the risks of radon, including in relation to smoking*” and that “*Member States shall provide as appropriate for the **involvement of stakeholders** in decisions regarding the development and implementation of strategies for managing exposure situations*”.

The case studies carried out in ENGAGE covered the following topics:

- Communication and management of intervention in the case of a school with a high radon exposure level in Belgium, with a focus on i) the dynamics of local actors (local public administration and authorities, inhabitants, teachers & parents, medias) in case of radon exposure

in sensitive public infrastructures (e.g. primary public school); and ii) the interactions and communication patterns between professional experts (local and federal levels) and the other stakeholders;

- The implementation of the national radon action plan in Slovenia, with focus on the requirements and practices for communication and stakeholder engagement in place, the challenges faced in the implementation, and the lessons learned;
- The role of stakeholders in radon risk and prevention in Italy, investigating the role and significance of different stakeholders' involvement in radon risk information and prevention, highlighting which stakeholders are involved in an active way, their different levels of involvement, and the exchange of views and experience, and observing, where relevant, the trends in relation to stakeholder involvement.
- A cross national analysis of radon websites from national and local authorities in eight European Member States, from a stakeholder engagement perspective, highlighting best practices related to the availability of radon information, accessibility, stakeholder interaction, dialogue, responsiveness, content and design, and transparency and openness.

3.1. Belgium- Policy of radon control in Wallonia: Communication and Management of intervention in a case of high radon exposure level

3.1.1. Description of the case study

To answer the question “How to make arrangements for public involvement in relation to radon exposures and the management of health risks?”, key stakeholders should be identified, together with their engagement mechanisms and roles.

Detection of high radon exposure levels may lead to situations where crisis communication might be required. Examination of both cognitive (hazard) and affective (outrage) responses, related to anger, suspicion, fear, distrust, and contempt, is important for crisis communication. This requires very detailed and context sensitive cases studies, as the dimension of “outrage” is very much linked to a specific event and to qualities of communication procedures such as agency and responsiveness. Sandman et al (1993)¹ proposes that the “cultural seriousness of a risk” is very much event specific.

In terms of communication and management, the central question for each actor in the crisis will be “Who to blame?” and “Who to trust?” while considering that:

- There is a plurality of values for different stakeholders,
- There is a plurality of trust levels towards local authorities,
- There is a plurality of trust levels towards experts;
- There is a plurality of agendas (for further action) by the local administrations and the different authorities.

A specific concern in Belgium is the distribution of responsibility between the authorities: this dimension justifies the choice of a systemic approach

- | | |
|----------------------|-------------------------|
| Product regulation | = the federal Authority |
| Internal Air Quality | = the Region |
| Health prevention | = the Community |

¹ Sandman PM, Miller PM, Johnston BB, Weinstein ND. Agency communication, community outrage, and perception of risk: Three simulation experiments. Risk Analysis, 1993; 13:585–598

Public Health protection = the local authority for public information about a local risk, and for the management of public infrastructures

The analysis of stakeholder engagement in relation to public exposures to indoor radon in Wallonia has to take into account that the distribution of responsibility in the federal Belgium is complex. One of the difficulties in mobilizing political actors around the issue of radon lies in the multiplicity of instances of power which are called upon to coordinate their actions as well as in different political choices for approaching this issue. In Belgium, three vertical levels of power are involved in the issue of radon for risk analysis and risk management: the federal, the regions and the provinces. Then the municipalities at the very local level.

This case study addressed the issue of radon risk communication and management in a public school with a high radon exposure level. The case is summarized below (extract from interview with the local administration and the SAMI).

Case study: Uncertainty at the school of a local public school

We placed the detectors on October 16th 2015 until January 20, 2016. Everything was sent to the laboratory and the results were a little bit what we feared based on the maps with the radon areas: Strée, etc. was close to zero; Vierset, around 100 Bq. And there, we had our School of Modave: on one side of the building, we had 200 Bq for the part with the cellar, and for the other part we went up to 1240 Bq. Then we followed the guidelines of FANC and made a complementary study for this building: it did not decrease. So we HAD to find a solution, by any means, to arrive below the reference level: we had an obligation of result.

Then we were told to contact the SAMI from the Province of Liège, a doctor specialized in radon management. He came on the spot, he placed his own detectors uh ... we agreed with him what to do. Make a hole in the wall outward and place a simple small fan to extract, to see what it gave. It crushed the radon rate, just with a bathroom fan that costs 19 € and will shoot for 5 years before falling out of order: complete solution! So with this little fan, we had fallen back to doses that ranged from 300 to 500 Bq, and then the doctor said: "We go to the right, we need good ventilation and we will be able to solve the problem.... And so we did. For the last control of the federal agency, and we fell to 60 Bq after the latest results. Then we placed, no longer a small fan, but something professional, and a double flow system continuous in the classes. "

The doctor from the SAMI reassured quite quickly saying: "OK, it's okay now, we see where we will go, no unnecessary stress. There is a problem, we will solve it. .. it's true, we touch the ceilings, but there are solutions, we must not believe that everything is lost." So we already work much more serenely. And we are already looking for solutions ... that, it is already good. He was a good guide: he brought us peace of mind by his skills .. and always clear answers right away to each question.

This crisis is less a health crisis than a political one, when local authorities had to face the teachers, parents, other political parties and the media... At the information session with the parents, there was a certain tension: politicians were present, as well as the media, but the doctor was the only one to speak. He was able to buffer the tension between the public and political authorities and he calmed the game, asking the public to give the local administration time to act.

As for the population at large, there have been few reactions. There are many who do not become aware: on the whole entity, 20-25 people who have checked during the campaign just after the check in the school! We had just tested the school ... and 30 families had been concerned with their children and we do not even have thirty families who have tested at home after. It's a little challenging ...

(extracts from interviews with responsables from local administration and SAMI)

3.1.2 Objectives

The objectives of the case study were twofold: i) to identify the dynamics of local actors (local public administration and authorities, inhabitants, teachers & parents, medias) in case of radon exposure in sensitive public infrastructures (primary public school); and ii) to analyse the interactions and communication patterns between professional experts (local and federal levels) and the other stakeholders.

3.1.3 Methodology

The methodology consisted of:

1. Desk research: public policy for radon control in Wallonia
2. Analysis of a case study concerning a local event of radon exposure (2017) in a primary public school through:
 - a. interviews with the local actors (public administration, authority, teachers, parents, inhabitants)
 - b. analysis of media coverage
3. Interviews with two local (provincial) experts and a federal expert addressing the question of how to integrate radon (a federal responsibility) in the prevention policy against indoor pollution (a regional policy)?

3.1.4. Analysis and results

Plural authority management

For the Southern part of Belgium (Wallonia), three administrations are directly interested in the topic of radon and particularly the risk assessment step: the federal agency for nuclear control (FANC)², the regional permanent health environment cell (CPES) of Wallonia, and the provincial services which have recently developed SAMI groups (Service d'analyses de milieux interieurs) in charge of indoor pollution (actors organized at province level). At the level nearest to the population, the local authorities (communes) have a large series of subsidiary responsibilities in terms of public health, environment and territorial planning.

The federal authority (FANC) is very much associated to international and European activities related to this issue. It is in charge of designing and assessing the Federal Radon Action Plan for Belgium. The problem of radon exposure in Belgium is only one of its matters of concern. Officially, FANC has three missions in terms of radon. First, it controls the dwellings in close collaboration with regional, provincial and communal authorities. On the website, this component also includes guiding the owners in the corrective measures, as well as the mapping of risk areas. Secondly, it controls the level of radon in workplaces of class 2 municipalities (radon prone areas) and assists the public authorities if corrective actions are necessary (the federal authority is in charge for health protection of the workers). Third, it develops a communication plan to inform on the theme of radon, to propose solutions and raise awareness in the population to convince citizens to take the measurement test and adopt remediation measures when necessary.

² AGENCE FEDERALE DU CONTROLE NUCLEAIRE, « Radon, le rôle de l'AFCN », disponible sur : <https://afcn.fgov.be/fr/dossiers-dinformation/radon-et-radioactivite-dans-votre-habitation/radon/role-de-lafcn>, consulté le 19/04/2019

At the level of the region, the permanent cell health environment (CPES)³ “maintains the link between the population and the Walloon institutions as regards the daily problems associating environment and health”, radon being part of it. In concrete terms, its website relays FANC information but refers to SAMI’s. The recent “Plan wallon environnement-santé 2019-2023 ENVieS “ presents the objective to better integrate the existing measures of radon levels (to be provided by FANC) in the set of indicators and maps on environmental pollution which is under development.

The issue of protection against radon in new buildings is now mandatory in line with the European directive 2013/59 EURATOM: “Member States shall ensure that appropriate measures are in place to prevent the entry of radon into new buildings. These measures may include specific requirements in national building codes. » (Article 103 par. 2). The new building code mentions the mission of the architects to take active and passive measures to address the risk “where appropriate”.

The Superior Health Council (SHC – the scientific medical authority)⁴ presented a report in 2017 on Indoor Air Quality with a whole section on radon. It recommended for radon prevention to establish a building code at all levels of legislative competences. For new buildings, prevention techniques consist of assuring the air-tightness of the building with respect to the soil (sealed conduits and ducts, radon-proof membrane, air-tight basement doors) and by the installation of a permeable layer below the slab that can be depressurised if necessary by means of a fan (SHC, 2017).

This question requires collaboration between the federal authority, on the one hand, which is responsible for the development of assessments and regulations on radon (including the regulations on building materials which might be a source of radiation), and on the other hand, the Walloon Region which is competent in terms of territorial planning and building standards through the regional code (CODT).

In Belgium, there is no “hierarchy of norms” between the federal and regional levels: it means that the federal authorities cannot impose actions or regulations in domains where the Region develops its own competencies (e.g. environment and territory management). Natural risk assessment and management linked to the territory are now under the authority of the Region, except for radon risk assessment which remains federal with all the issues for radiation protection. Similarly, the health-environment questions are now under the authority of the Region, except for the working environment, which is still federal. To ensure a proper enactment of an active policy in such a complex political sector, it is necessary to develop flexible communication mechanisms between the levels of power and transversal to the dimensions of the issue at stake.

The SAMI⁵ are the provincial environmental analysis services for indoor pollution. They contribute to the campaigns for radon measurements coordinated by FANC, provide the detectors and organise the transfer of information between the laboratory and the applicants. In case of need for mitigation, the SAMI’s can give support to the owners (private or public) for the design and follow up of the sanitation action plan: this support is proposed free of charge upon request. This makes the SAMI’s the main public experts for radon risk management.

³ ENVIRONNEMENT SANTE WALLONIE, « Cellule permanente environnement santé » disponible sur : <http://environnement.sante.wallonie.be/home/en-wallonie/cellule-permanente-environnement-sante.html>, consulté le 19/04/2019

⁴ SHC, 2017, Indoor air quality in Belgium, ADVISORY REPORT OF THE SUPERIOR HEALTH COUNCIL No. 8794

⁵ PROVINCE DE LUXEMBOURG, « Citoyens, le radon en Province de Luxembourg », disponible sur : <http://www.province.luxembourg.be/fr/radon-en-province-de-Luxembourg>. consulté le 19/04/2019

Resistances at each level of authority

At the federal level, resistance seems to be linked to the specific Belgian North / South language divide. In the northern part of the country, the probability and extent of radon exposure are very low. Therefore, the radon situation and the objectives of the campaigns are different in Flanders and Wallonia.

In 2001, the first national indoor radon measurement revealed the average indoor exposure of the Belgian population of around 50 Bq/m³. The table below shows the difference in exposure in the north/south of the country. In Wallonia, out of 1.325.000 dwellings; 26% might be above 100Bq/m³ and 1.6% above >300 Bq/m³. In radon prone areas, 17% of the 130.000 dwellings are estimated with a level of exposure higher than 300 Bq/m³ (SHC 2017)

Table 18. 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

In Flanders, few homes are affected by the problem and so there is a desire to maintain the "stand still" as the question is not much on the political agenda. In Wallonia, the situation is the opposite, the risk of exposure to radon is higher. So the federal authorities can eventually receive demands to address the problem in Wallonia with providing enough resources for communication, risk assessment and mitigation: the demands are then addressed to the provincial SAMI's.

The provinces are very active in the field of radon, mainly through their SAMI's, the provincial units in charge of the issue of indoor pollution: these units usually combine technical and medical expertise. The involvement of SAMIs for the radon risk management is recognized as quite important and the respondents express somehow in their interviews their feeling that the issue, particularly the remediation, is not adequately addressed neither by the federal, nor by the regional authorities:

"It's not at the Walloon level, neither FANC at the higher echelon they will take care of ... a few tens of thousands of people in the province of Luxembourg huh!"

SAMI's are supposed to work closely in contact with FANC: it is FANC which defines the procedures for measurement of radon and which puts together all the data from the country in their database and on their map. The SAMI's of the different provinces collaborate with FANC for the annual measurement campaign which is proposed to all residents in Wallonia since 2013: nearly 12.000 measures have been reported between 2013-2018 (in Wallonia and Bruxelles)⁶. SAMI's can provide detectors and then analyse them and can give individual advice when necessary, if the level of radon is higher than the reference level: this is done in collaboration with FANC.

The interactions between the SAMI's and the local authorities are considered as very supportive, particularly with reference to efficient risk management and communication. In case of measurement of high levels of radon, the SAMI gives technical support to the municipality in a proactive and problem solving way which tends to reassure the municipality in case of problems (see the case study). In

⁶ La politique publique d'amélioration de la qualité de l'habitat privé en Région wallonne, Rapport de la Cour des comptes transmis au Parlement wallon, mars 2019

matters of communication, the SAMI also supports upon request the local authorities and organises public conferences, focus groups and other activities. The audience are municipal authorities and administrations, the population, doctors, medico-social actors, architects and building professionals.

SAMI's tend to act as "brokers" between FANC (and their European obligations in terms of risk assessment) and the local authorities. Interactions with regional actors are however very limited.

At the Walloon (regional) level, when it comes to radon, it is the CPES (permanent cell health environment) which is in charge of this them. CPES is situated in an ambiguous position under the control of three ministries: Environment, Territorial Planning and Health. This position does not give to CPES the possibility to develop strong projects, as each of the referent ministers have de facto a veto power. This complicates the collaboration between CPES and their partners. Experts at FANC and at SAMI's deplore the lack of power of the cell caused by their position and the resulting blockage observed at the level of the region.

"So, this CPES I said to myself, "OK, it's with them that I have to talk, them, they have to implement all that. "Uh ... but the problem is that they depend on different ministers. So they may have a skill but they have no power direct. So they can come up with something but in the end it's the government that must implement uh ... decisions. And that's where ... well ... for now, it's blocking." (a federal expert)

In 2015, the regional authority acted as an employer to launch a measurement campaign in all the public buildings on the territory of Wallonia; it was on this occasion that high concentrations of radon were found in some local public schools and these were events that served as case study.

It is also at the regional level that some questions emerged about risk management and the issue of resources availability: risk assessment and risk communication generate costs but which authority would cover the mitigation costs, which are much higher? In case of high radon levels, how would the value of houses decrease? These two economic questions are often mentioned as possible concerns for policymakers who would prefer to not talk about the issue. However, the regional authority currently proposes some premium (100-1500 euros) for the remediation: up to now, only 14 premiums have been distributed, which is low in comparison to the number of tests (12.000).

The 2019 report of the Court of Auditors to the region concerning the quality of private dwellings including radon proposes to the Walloon authorities to adopt a more proactive stance to better take into account the risks related to radon pollution: the problem of radon should be addressed in an integrated way, e.g. by conditioning the granting of bonuses (for energy savings) in buildings located in a zone of significant risk, to the absence of radon or the implementation of priority measures to eliminate it. *Otherwise the Walloon Region might subsidize renovations and insulation work in radon-polluted dwellings and by this intervention boost radon levels. (Cour des Comptes, 2019)*

At the local level, the municipalities in the risk prone areas are more disposed to support the FANC and SAMI's efforts for a better local radon testing. Nevertheless they report their concerns about the financial impact of these measures.

Neighbouring municipalities also felt concerned by the issue of radon, but they were afraid to embark on the process of measures for fear of having to make too big investments (a local administrator ... after the crisis)

Common concerns for a better communication towards their publics

The FANC, the SAMI and the municipal authorities share a common concern to adapt their discourses: they have to consider the objective of communication, the type of audience and the context of communication.

Case 1 : The objective might be to support a risk assessment campaign in the general public (not in high risk areas) to convince all residents to perform the tests: this means to involve the local authorities in the communication process, as they are used to launch such communication on their territory.

At the level of FANC, they wish to improve the perception of risk of the public by deconstructing the argument of nature.

"If we say that something is natural, we see it very quickly as not serious, good for health, uh ... fatalistic.. So in order to change that, we identified a track that was to say, in our awareness campaigns, to show the public that radon, yes it is natural, it's clear. But having a lot of radon in a building is not natural! This is entirely due to the way in which the construction is built... So although radon is natural, to have a lot of radon in a house is a recent trend and it is not natural at all!"

At the level of SAMI, the adaptation of the discourse is also done in relation to the cartography of the risk areas. They tend to really nuance the message on the maps, to underline that even if an area is depicted in green colour, there are sometimes places where there is radon. The SAMI are associated to the FANC campaigns and sometimes receive regional supports; however these are marginal.

Case 2 : The objective might be to support a risk assessment campaign in the general public in high risk areas to convince all residents to perform the tests and to further invest into remediation: this means to involve the local authority in the communication process, as they are used to launch such communication on their territory, and the SAMI as expert for mitigation.

The provincial SAMI's play a major role for mitigation. They are also reactive and ready to support local authorities, as well as individual homeowners facing a high radon measurement level. This individualised communication process is legitimated by their concerns for problem solving: they consider that radon is very dangerous and should be a priority concern in the control of indoor air quality, and that solutions exist BUT their implementation must be tailored to the very contingent specificities of each local and individual dwelling. The discourse must be considered stepwise: how to convince the population to make the test? how to convince the population to come to get advice for remediation when necessary? how to do this properly?

" my job is not to scare them, but to reassure them! and also to give them advice for remediation work and to encourage them to do it properly."

Case 2b : the same for public administration.

In the current situation, when the municipality has a long experience with radon exposures and sits in one of the high risk zone, the local administration has experience with radon and keeps contact with the provincial services SAMI when necessary.

If the municipality is not situated in the high risk area, there is a high probability that neither the administration, nor the political authority, would have heard about the problem before and that the local administration just contributed to the implementation of a radon campaign decided and organised at the regional and federal levels. Then, if the results are bad, the local authority has little expertise and does not know what to do, where to go, in terms of possibilities for remediation and for communication to the public and the media.

For their own workplaces (such as shown in the school cases), when they are facing a very high level of radon in one of their own buildings, the local authorities have to face some form of "political" crisis with the publics, the media and the political opponents. As underlined by one of the administrations, when a large radon assessment campaign is organised (as the one in 2016, targeted to all the buildings used by local public administrations in Wallonia), it would be better to have a larger information to the

public when launching the procedure and to organise this with the active support of the municipality. This is deemed to help avoid the expression of suspicious concerns by the media and the public, and facilitate the information procedures by the SAMI medical and sanitation experts in case of crisis. Being informed before the crisis, and before launching the whole campaign, helps integrate the following steps in the action plan and the test results would then not come as a surprise:

What is a crisis? we can speak of crisis when the event poses problems that have not been integrated into the institutional structure, with uncertainties that contribute to exacerbating antagonisms and exposing organizational ambiguities (Fallon et al. 2008)⁷

This underlines the importance to consider within the common perspective the two moments of risk management. The analysis and planning steps are the time for reflection, proposals, ex ante evaluations, while the emergence of the event is the time for adequate and quick reaction. In terms of communication, it supposes that the discourses at the start of planning already put in place the necessary basis for a right communication process (the basis for trust and expertise), should an adverse event occur requiring the public intervention.

Case 3 : Communication with the promoters of new construction projects

At the regional level, the new planning regulation (CODT, 2017) mentions radon, in line with the requirement of the European directive 2013/59 EURATOM: the regional law imposes for the permit of a new building,

"to describe where appropriate the active technical measures and passive, planned by the architect to prevent or minimize the risk with regard to the zones defined by the FANC and in relation with the action plan regional level in the fight against radon" (CODT – Annex 4)

This means that the responsibility lies with the architect. But the term "where appropriate" is blurry: in which case are these measures necessary? It is not possible to measure radon as long as it's not confined to a building. For the architect, it is NOT possible to use the interactive map which is at a too large scale to define what the risk in a small plot of 1000 m². The federal map should soon be integrated in the Walloon GIS systems for natural risks, together with the information about flood risk, or karstic risks.

At the level of the local authorities, radon exposure seem to not be an everyday concern. Only in high risk areas, the local planning services in charge of giving building permits for new constructions would inform promoters that it is better to place a plastic membrane anti-radon. But this is not a formal obligation and there is no request for specific risk analysis by the local service.

Mapping risk zones for radon: a tool dangerously reassuring?

All the actors we met agree that radon is not very known to the population.

"There are some people, but a minority of people who know the subject. And very often, that it's a radioactive gas and a lot of people do not even know the effects on health".

However, they point out that there are disparities in the level of knowledge, depending on the territory concerned. Indeed, as explained by the expert in FANC: *"In the province of Luxembourg, for example, many more people are informed. They know what it is and know the risks, the solutions {...} ...much more than, for example, in West Flanders"*. This observation is also verified by the discussions

⁷ Fallon C. et al., 2008, La planification d'urgence sous tension. Cahiers de la Sécurité, 3(Janvier-Mars), p.72-83

undertaken with urban planning services classified in risk zones. Respondents confirm that they have been aware of the problem by living in a region concerned by it. *"(I learned about radon's) because I built a house so I learned a little bit and then I had heard about it in the press, and that sort of thing."*

These differences can be explained by the fact that *"awareness raising campaigns focused especially on areas at risk"*.

The definition of risk zones for radon is a European obligation in the Directive 2013/59/EURATOM (Article 103 (3)): *"Member States shall determine the zones in which the concentration of radon in a large number of buildings should exceed (as an annual average) the relevant national reference level"*.

In Belgium, this determination takes the form of an interactive map which is produced by the federal authority for radiation protection (FANC). According to FANC, the advantage of this format of cartography is that it is a tool very useful for raising awareness by showing where the risk is above average.

However, this map is criticized by the local actors for two reasons.

On the one hand, the probability of measuring a level of radon much above the recommendations in dwellings is not limited to risk areas as they are defined by this tool. In other words, it is possible to have a high concentration of radon in a building located in a "green area" on the map.

On the other hand, this categorisation tends to demobilize the part of the population that lives in an area that is NOT is not referred to as a risk zone on the map. For instance, SAMI Luxembourg, in charge of indoor protection in Southern Belgium, speaking about the participation of the population in the radon measurement campaign, considers that the map contributes to demobilising the local authorities which are NOT in the red zone:

"Because in fact, when there are the maps and when it's green, people say "there is no radon here!" So we have to really nuance the message we're getting with the cards: that even if it is in green, there are sometimes places where there is radon .. "It is said that it is principally Neufchâteau and Bastogne {the two districts at highest risk}, but there may be elsewhere. And when we say it's mainly Neufchâteau and Bastogne, and well the other districts they say: "Oh well it's not for us!"."

A medical expert who put in place the SAMI in Liege district argues that the map is misleading because these large coloured zones convey the idea that radon measurement is somehow uniform in a local zone, while the experience shows the contrary:

- In a low risk zone (Hesbaye) where the lime cover might be thin, ground work, for example for building a new house, might create a chimney in contact with limestone rocks and cause a high local production of radon ;

- In high risk zones (Luxembourg with a rocky shale soil), the mean level of exposure is known to be higher than the new reference level (100 Bq/m³). At the same time, most people are not aware that the exposure values are widely dispersed and the value of the mean should not be used as a reference at the commune or village level.

"It's important to understand that in the Ardennes, overall, the whole population is more exposed, but individually they are exposed at lower level than the people living in Hesbaye... » (which are less numerous but exposed to a large concentration when it occurs)."

Indeed, in areas that were not considered at risk according to the FANC map, and thus where the population is less aware of the topic, there can be radon levels far superior to European recommendations.

The accuracy of the map depends on the number of measurement points and the granularity of the representation of these measurements. This is reported to be misleading by the local experts (local administrations and provincial SAMI administrations in charge of indoor air quality). For this reason it is important, when there is a suspicion for hot spots, to control all dwellings in the local area. As reported by the local administrator in the case of Modave's school, during measurements of their public buildings, they found astonishing disparities in the results of buildings nearby.

In addition, we were challenged at the level of administration and of the political authorities because we had the problem at the school (1200 Bq) but you go up the street 50m, there is another public room (50 Bq). And we go up 100 m, there are the buildings of the CPAS, and there we were at maximum 100Bq. So in 150 m, we go from 100Bq to 1200Bq. And so, it can come everywhere, anywhere ... Why? How? Uh ... just the geological faults that's all. But as we do not know them, it may be necessary at the time, for the population, ask questions and place a small detector."

Currently, there are still large differences between the divisions of the map and the situation on the ground and this problem, added to a negative impact of radon exposure to the health of the population, is problematic in terms of risk communication to the local authorities and the population.

FANC is quite conscious of this disadvantage of this kind of map. But according to the agency, the problem is not the meaning of the tool, but rather the lack of understanding of the public and need for more explanation.

"The map indicates that the risk in areas that are green is less than, for example, 1%. So the probability of having too much radon is less than 1%, that means, that does not mean that there is no risk. So if in a city or common of 5000 houses, uh ... 1% that represents uh ... still 50 houses. So it's not that there is no risk. But sometimes people say, "OK, my is green, so I'm not doing anything ", although there may still be 50 houses that have a problem in this municipality. ... we have to explain the ... uh ... the ... what does it mean reading a map... But it's with all the maps... it has the advantage of visualizing the distribution of a some problematic {...}, but there is a need for awareness and information give to the public who uses this map. {...}"

So finally, given the uncertainty of the dispersion of radon concentration on the territory, as well as the problem of public understanding of the tool that provokes demobilization, we can question the relevance of the choice of a risk zone mapping for local communication. Indeed, it seems counterproductive in the sensitization of the population by conveying an ambiguous message and dangerously reassuring aspect.

Another position might be to follow the proposal by the Superior Health Council and organise the campaigns for the whole territory (at least in Wallonia but maybe also in Flanders):

If the objective is to have an impact on the lung cancer incidence rate, the actions to reduce the radon exposure should not be restricted to radon prone areas, but also to reduce the average concentration in less exposed areas. This also illustrates the importance to avoid in the future an increase of the average radon exposure in areas where this exposure is still low today. Possible risk factors for such an increase are changing building techniques and a general trend towards low energy buildings. (SHC 2017)

Collaboration and tensions between the different levels of administration

The case study showed the importance of organising good cooperation between FANC and the SAMI's, as well as with the local authorities. However, field work revealed lines of tensions.

The distribution of responsibilities and tasks between FANC and the SAMI's were not always very clear and there was some form of rivalry between these services for the organisation of radon measurement campaigns. These are divided into two parts: workplaces and residential dwellings.

According to the FANC, SAMI's deal with residential dwellings and FANC is in charge of controlling workplaces. The two services had to decide how to organise their work.

"For example, in the radon measurement campaign, so the work places, this is not really the provinces that deals with it because in fact they, SAMI are competent only for the environment in private places. So they also do schools and nurseries. But it was not clear to what level they could be involved in the workplace parts." (FANC experts)

However, in practice we continue to observe areas of blur. The case of schools is an enlightening example. While FANC thinks that schools as other public buildings are within its competence, in fact, both services, FANC and SAMI intervene but they provide different expertise: SAMI support the local transformation of amenities to reduce the concentration of radon, while FANC controls that the final concentration is below the reference point. On the field, SAMI provides support to the local authorities not only to give very practical advice to solve the problem of radon concentration, but also to inform and reassure the population. The expert can at the same time present and discuss the technicalities of radon exposure, the possible health impact and the importance of the type of remediation measure.

At this information session with the parents, there was a certain tension. Politicians were present but I was the only one to speak. Political authorities were happy to have me as a buffer to calm the game and ask the public to give us time to act. (SAMI expert)

In summary, by providing solutions, this expert accompanies, supports, reassures and communicates with the population and the communal authorities. Their expertise is the result of experience, being confronted with very different problems and the need to find a solution.

"But finally, by seeing houses, by finding solutions (or not) there are things I think about right now: the experience and the number of years and the number of visits make me little smarter now than ten years ago". (SAMI expert)

On the other hand, the role of FANC experts is rather perceived as that of the controller, who comes to check the radon concentration after the remediation measures have been implemented in the building.

There is a strong dichotomy between the approaches of the two administrations.

First, in the way of acting. The experts of SAMI's focus on cost-effective procedures and solutions:

"So I always start with what costs nothing or not much and if it does not work then we move up a gear." When the FANC takes care of the remediation: "Or he sends the kind of geologist team ...they make you chimneys and they put aspirations over the roofs, etc. It's always gone for thousands of euros and we must drill holes, etc." (SAMI expert)

This concept of cost is important because it is very often pointed as the main demobilizing factor for action on radon due to fear of excessive costs of the remediation work: it should not cost thousands of euros. This is true for private owners as well as for the public buildings.

Second, when considering their missions. While FANC and SAMI seem to share communication missions for radon measurement campaign and awareness of the population, the FANC is interested mostly in regulatory development and statistical monitoring of data: its civil servants feel responsible for the respect of law and the proper translation of the European directives such as the identification of risk areas or the awareness of new builders.

This attention to federal and European reporting is not the priority of the SAMI's agents: these are more focused on taming and adapting to the field in their search for efficient and cheap solutions.

"Ah, but me the results, they do not interest me, me what interests me is that there is no more radon in homes and that people are aware of their specific exposure."

The objectives and the way of acting (communication and interventions) are very different. Can they be considered as complementary?

For large radon campaigns, the main objective of FANC is to collect data.

For all the radon campaigns (federal, regional or local), the objective of SAMI's is to make sure that the population is not exposed anymore to large radon levels. This means that, while they are not the main designer of the campaigns, they nevertheless take in charge the local expertise necessary for proper remediation. For this second step, they can only act if the owner call them for help, because he/she is convinced that the risk is high and that the intervention will be efficient at an acceptable cost: actually, less than 50% of the private owners with a high level of exposure take contact with the SAMI Lux, which is much below the expectations of the service.

Other findings related to stakeholder engagement

What levels of awareness about external prescriptions for stakeholder engagement in radiation protection do researchers, practitioners or stakeholders reveal?

In general, there is no awareness about "external prescriptions for stakeholder engagement". The level of awareness about radon itself did not increase much, except in some areas considered as very high risk. This is true not only for the population at large (even in area with a high mean radon risk), but also for the architects and building professionals. The medical doctors know the name of "radon" but not much more: they seem to be more mobilised on "indoor pollution" in general, and less so on radon (in the case of radon, there is no need to have a medical signature to contact the SAMI).

How is stakeholder engagement is understood and practiced (at individual and institutional level)?

The provincial medical experts first organised local meetings in the evenings in municipalities with high risk. However, this type of meetings does not work anymore. It seems better to use the social networks. The message was also adapted: *"some years ago, we were very careful to not scare the people... but now we find that it is necessary to panic people – a little- so that they take the initiative, e.g. to measure but also to remedy if necessary."*

The possibility of asking for a radon detector on line at any time of the year and not only during the campaign is a good practice. But what is most efficient is an unaddressed post-delivery to all houses in the municipality with the support of the local authorities.

Trainings are provided for the architects and building professionals, among others, but the participation is very low. The building professionals do not feel concerned and they do not believe in the interest to put a waterproof plastic cover on the soil.

What were the rationales for stakeholder engagement, the final objectives? Has there been a critical evaluation of the attainment of objectives and of the impact of stakeholder engagement? Have there been any guided improvement activities?

The campaigns did not change a lot. Only the cooperation between the level of the province (the unit in charge of indoor pollution) and the federal agency did improve. The federal agency coordinates the

whole process and controls the impact of mitigations when necessary; the provincial unit comes on site to help find a solution when mitigation is necessary.

The provincial units also organise specific communication activities upon request by the local authorities and organise public conferences, focus groups, and other participatory activities. The audience are municipal authorities and administrations, the population, doctors, medico-social actors, architects and building professionals.

In the areas with very high risk, the participation for radon measurement has increased, but the percentage of homes asking support for remediation is too low.

What are radiation protection actors and communities doing that may de facto count as stakeholder engagement (but are not necessarily labelled that way)?

As underlined by one of the administrations, when a large radon assessment campaign is organised (as the one in 2016, targeted to all the buildings used by local public administrations in Wallonia), it would be better to have a larger information to the public when launching the procedure: it would help avoid the expression of suspicious concerns by the media and the public, and facilitate the information procedures by the SAMI medical and sanitation experts.

What are the benefits of implementing stakeholder engagement processes (in the situation studied)?

A better communication involving the stakeholders would increase trust in the quality of the tests and in the real expertise of the SAMI experts.

If there is a higher trust between the stakeholders and the administration, and if the administration helps with a “problem solving” approach, there is a better chance for an increase in remediation (in number and in quality).

What are the lessons learned for the establishment of efficient stakeholder engagement processes? How did the local administration integrate the dimension of radon protection in their practices (e.g. Urban planning and permit delivery)?

A proposal was made that the risks related to radon pollution should be addressed in an integrated way together with other policies, e.g. by conditioning the granting of bonuses for energy savings investments in buildings located in a zone of significant risk, to the absence of radon or the implementation of priority measures to eliminate it. This would be a way to spread the message on the need for radon remediation.

3.1.5 Conclusions

Radon is a public health problem, as much as an environmental problem, an economic problem, and an urbanism / building problem, which means in practice there are many fields of responsibility, both private and public.

The case study showed that administrations at different levels act differently, with different objectives at different moments, and do not mobilise the same risk analysis approach. Distribution of responsibilities and tasks between the different authorities were not always very clear and the strategy for global communication is haphazard. The whole system suffers from the absence of investment of the regional level and the absence of consistent and global communication patterns about the risk assessment.

Adjustments in the communication strategy on radon have been made. The most relevant means highlighted are: a web platform to order a radon detector online at any time of the year, information

through social networks, free large scale newspapers, but also through an unaddressed post-delivery to all houses in the municipality with the support of the local authorities.

Radon is at the same time a public health, an environmental, an economic and an urbanism issue. The adoption of an integrated approach of environment-health issues together with urban planning and energy saving policies would favour the involvement of citizens and the adoption of protective measures.

Given that the top down approach has not been effective for private houses, the utility of risk assessment can be increased by clearly linking it to context sensitive risk-management options, in order to inform the decisions of those in charge of risk mitigation about the available options.

Furthermore, action oriented research (e.g. citizen science) with case studies is necessary to better understand the interactions between stakeholders engaged in different policy issues and / or at different levels of responsibility in a web of multiple frames and constraints.

3.2. Slovenia: implementation of the requirements from the national radon program

3.2.1. Description of case study

The case study focuses on the implementation of the requirements from national decree on the national radon program in practice, especially on the approaches to raising awareness and other communication practices with the target audiences. The Slovene Government adopted in 2018 with the national decree all related requirements from the BSS Directive in relation to national radon program and also defined the responsible stakeholders for its implementation.

3.2.2 Objectives

The objective of the case study is to:

- Investigate what are the practices of stakeholder engagement in place related to requirements from the decree, and
- what recommendations and/or lessons learned can be pointed out.

3.2.3 Methodology

Analyses included investigation of Slovenian relevant legal framework, information available on webpages and a review of relevant published documents.

In addition, interviews were conducted, with a representative of the Slovene Radiation Protection Administration and an authorised expert for measurement and assessments of doses to the public. Collected data were recorded and analysed to answer the questions for ENGAGE WP2. The results of investigation were compared with the legal requirements. Good practice and/or recommendations are identified.

For the purpose of this investigation the following WP2 questions were considered from deliverable “Report on key challenges, best practices and recommendations for stakeholder engagement” (D2.1 of ENGAGE):

- What levels of awareness about external prescriptions of stakeholder engagement in radon field can be revealed?
- How is stakeholder engagement understood and practiced (at individual and institutional level)?

- What were the rationales for stakeholder engagement, why it was implemented? Has there been a critical evaluation of the achievement of objectives and of the impact of stakeholder engagement and what were results? Have there been any guided improvement activities?
- What forms of acceptance, resistance, denial, or adjustment of engagement do you observe or encounter? And how do these forms change over time?
- What are responsible institutions doing that may de facto count as stakeholder engagement (but are not necessarily labelled that way)?
- Which challenges and opportunities do you encounter for stakeholder engagement in your specific case?
- What are the benefits of implementing stakeholder engagement processes (in the situation studied)?
- What are the lessons learned for the establishment of efficient stakeholder engagement processes?

The interview protocol used for the purpose of the study with the following information:

- o What is the role of the organisation in the field?
- o What is the role of the interviewee in the organisation?
 - **TOPIC 1. Awareness and acceptance** - what did you experience regarding the awareness of and acceptance /resistance to stakeholder engagement by different actors for radon management;
 - **TOPIC 2. Other forms of engagement, for instance non-institutional** - what did you experience in other forms of engagement, like initiatives by citizens or civil society groups;
 - **TOPIC 3. Practice of stakeholder engagement** - what are the motivators for stakeholder engagement in practice? What is the role of external prescriptions or recommendations? What constitute a good engagement process?

Specifically, interviews focused on the following questions:

1. Are the requirements from legislation about involvement and participation with stakeholders implementing in practice?
2. Which activities and how from article 12 of decree on national radon program are the actors implementing?
3. Who is in reality implementing the requirement and how are the priority areas defined?
4. What are current problems? Where are there do possibilities for improvement?
5. What kind of advice do you provide, and do you have also adopted guidelines?

3.1.4. Analysis and results

Legal requirements

There are two basic legal prescriptions in relation to indoor radon:

- 1) The **Ionising radiation protection and nuclear safety act** (ZVISJV-1), Off. Gaz. 76/2017 – Atomic Act: which defines general requirements for the control of indoor radon (see Annex 1)

The Atomic Act stipulates, among others, that the government shall adopt a national radon program including also separate program to raise awareness among employers, the public and health professionals about the health risks posed by radon exposure, and the additional risks associated with smoking. This shall also include the importance of carrying out measurements of radon and measures

to reduce exposure. The program shall be developed for period of 10 years and every new revision shall include also the assessment how well the previous one was implemented.

2) The **Decree on national radon program regulation**, Off. Gaz. 18/2018, with provisions for:

- the management strategy for increased radon exposure, which includes goals and indicators for the successful reduction of health risks and considers optimisation of protective measures;
- reference radon concentration levels in working and living environments;
- criteria used for identifying areas with higher radon and special radiation protective measures in these areas;
- the method and the methodology for determining the annual average radon concentrations;
- the programme for systematic review;
- the method, type and scope of measurements;
- within the framework of statistical surveillance;
- taking measurements at workplaces and re-taking measurements to check implemented measures;
- the methodology for assessing doses due to radon exposure;
- the awareness programme for employers, public and experts regarding health risks due to radon exposure and additional risks related to smoking and the importance of taking radon measurements and measures on reducing exposure.

The awareness program stipulates that the Slovenian Radiation Protection Administration (SRPA), which is the authority responsible for radiation safety has the obligation to **provide information to the public, employers and local decision-makers through publications about health risks** due to radon exposure, particularly relating to smoking; **prepare guidelines on preventing the entry of radon** into buildings, including the identification of construction materials with high radon-release levels, and on implementing the rehabilitation of facilities and new buildings in areas with higher radon; **organise seminars, expert meetings and workshops on health risks** due to radon exposure; **warn that adequate air quality in indoor areas** must be provided where energy saving measures, such as energy rehabilitation and the installation of new windows, are implemented; **keep records on radon concentration measures** for indoor areas in accordance requirements of Atomic act; strives to realise the long-term objective of **reducing the risk of lung cancer**, by regularly defining risks due to radon in strategic documents on managing cancers, and in programs established for the healthcare of children and young people; within available financial means, **support research to improve understanding** of the effects on health of radon exposure; **publish a list of providers of works** with knowledge and experience in the field of suitable new constructions and the successful rehabilitation of buildings.

In the Atomic Act, provisions for communication with the public are basic with some provision of information on health risks posed by radon exposure. The Decree further defines ways to address the public in areas exposed to radon. It could be understood that such activities are based on a normative rationale (i.e. it is the right thing to do, it responds to a certain principle). Interaction with the public is also foreseen in the areas where there is increased level of exposure to radon for public and workers, and particular attention is given to the childcare, education, culture and health buildings.

The level of stakeholder engagement is mainly limited to provision of information by responsible authorities as required in Atomic Act, for raising awareness on risks posed by radon exposure. In the more detailed Decree activities to organise seminars, expert meetings and workshops on health risks due to radon exposure are also foreseen. These activities could enable space for interaction between participants, like discussion and involvement. The existing Slovenian legislation is providing basic requirements for stakeholder engagement. However, the implementation could be improved.

Radon websites

Slovenian Radiation Protection Administration

The Slovenian Radiation Protection Administration has a web site <http://www.uvps.gov.si/> with various information related to indoor radon. The content can be divided in the following:

- Legislative framework related to radon and link to the Atomic Act and the Decree on the national radon program, as well as annual reports on nuclear safety and radiation protection. This information includes also brief overview of legal provisions. If, on the basis of a systematic review, workers or individuals from the population receive more than 1 mSv annually due to radiation of gamma or other cosmic radiation or more than 6 mSv due to exposure to radon and to its descendants, the Inspector of the Radiation Protection Administration of the Republic of Slovenia shall order the implementation of measures to reduce exposure. The owner of the facility or the operator is obliged to carry out the measures. The provision of measures in kindergartens, schools, hospitals and other facilities intended for the implementation of educational, cultural, health or educational programs is provided by the state.
- Basic information about radon in Slovenia
http://www.uvps.gov.si/si/delovna_podrocja/izpostavljenost_naravnim_virom_sevanj/radon with information on what is radon, what are its properties, how it comes into buildings, what is the related risk, what can be done, the map of radon concentrations in Slovenia, how it is measured, what is the authorised institute for measurements, some requirements from the legislation;
- Audio record from the discussion with an inspector, a health officer and a construction engineer on Radio Slovenia 1: Studio at the 17th, February 2017 with the content - Over time, radon has been too concentrated in some kindergartens and schools, and is found almost everywhere, both in residential buildings and in public institutions. What is the cause of the phenomenon of radon in which radon is the most expensive building, how harmful it is and how can this perilous risk be reduced, which construction works are the most effective?
- Video contribution about radon on Television Slovenia: We bite science: How can we easily live with radon, October 2014, Radon is a gas that is all around us. It is constantly coming from the earth to her surface. It is colourless and odourless, so we do not notice it and we do not know if it's in our area. From the ground it also passes into buildings. And this creates a problem. Why? Radon and his descendants are trapped in the spaces where we work and live. In the enclosure, however, its concentration increases so much that it becomes harmful to our health. We will show you where everything is and how we can live with it easily.
- Link to ERA – European Radon Association <http://radoneurope.org/>.

Zavod za varstvo pri delu – ZVD – Institute for occupational safety

ZVD is the authorized operator for radon measurements and promotes on its web site <http://www.zvd.si/zvd/zdravo-okolje/radioaktivni-radon-brezplacne-meritve-po-sloveniji/> measurements of radon which are free of charge in some parts of Slovenia. The measurements are financed by the SRPA (however there are some limitations) and should be in line with provisions from the decree on the national radon program.

ZVD also provides information on how to organise the measurement of radon in homes by the owners of houses or other interested. The instructions are such, that the radon detector is sent based on request and left indoor for two months, then resent to ZVD for evaluation. The results of the measurement are then given to the house owner or interested. The areas of increased radon are

specified in the decree on national radon program and additionally defined based on results of measurements.

Finally, ZVD provides on the dedicated web site general information about radon for all interested stakeholders, such as what is radon and how it enters the closed spaces, why it is dangerous, statistical data about the lung cancers, location of areas with increased radon in Slovenia, what can be done in case of increased radon values.

Interviews

According to the **SRPA** representative, all 18 requirements from the BSS directive are transposed in Slovenian legislation. Some parts are in the Atomic Act and the details are in the decree on national radon program. Article 12 of the decree stipulates the activities required from SRPA in the framework of the awareness programme (see above).

The activities are performed within some flexibility and depending on the interpretation, but in general the SRPA tries to perform within their staff constrains as much as possible. SRPA responds in any case to any request from all stakeholders. Different actors are perceived as stakeholders: institutional actors (ministries, authorities and also municipality representatives) and also non institutional actors (experts, employers, NGOs, individuals, media, researchers, ...). The webpages of SRPA contain several information about radon and related risk, and this will be improved as the webpages are currently being updated (as it is indicated). For measurements of radon in the areas with increased concentration, they provide the resources and liaison with the organisation authorised to provide measurement at homes (ZVD).

The SRPA respondent highlighted that most of the activities stipulated by the national legislation are performed in practice:

- ***provide information to the public, employers and local decision-makers through publications about health risks due to radon exposure, particularly relating to smoking:*** SRPA provide basic information on webpages, as well as in the annual reports. In addition, whenever there is an inspection SRPA provides all related information. Especially unions are very interested to obtain information and also to protect employees. In all public buildings in the increased radon areas SRPA promotes measurements and also the measures for improvement of the situation.
- ***prepare guidelines on preventing the entry of radon into buildings, including the identification of construction materials with high radon-release levels, and on implementing the rehabilitation of facilities and new buildings in areas with higher radon:*** The guidelines for reconstruction are still under development, they were drafted together with an expert for construction from ZAG (Slovenian National Building and Civil Engineering Institute). The guidelines for new buildings are also under development and are sent to the Ministry of Environment and Spatial Planning for comments. The construction material is not so problematic in Slovenia.
- ***organise seminars, expert meetings and workshops on health risks due to radon exposure:*** This information is given at seminars and trainings which are devoted to professionals, but also at some other events, organised by other institutions (e.g. health institute, ...).
- ***warn that adequate air quality in indoor areas must be provided where energy saving measures, such as energy rehabilitation and the installation of new windows, are implemented :*** This is linked with activities on new guidelines;
- ***keep records on radon concentration measures for indoor areas in accordance requirements of Atomic act :*** Annual activity and reported in the annual reports
http://www.ursjv.gov.si/fileadmin/ujv.gov.si/pageuploads/Anglesko_LP_2017.pdf;

- *strive to realise the long-term objective of **reducing the risk of lung cancer**, by regularly defining risks due to radon in strategic documents on managing cancers, and in programs established for the healthcare of children and young people: Development of a brochure about radon;*
- *within available financial means, **support research to improve understanding of the effects on health of radon exposure** : There are very limited resources, but there is support to the institutions which are involved in EU research projects in the frame of H2020;*
- ***publish a list of providers of works with knowledge and experience in the field of suitable new constructions and the successful rehabilitation of buildings**: This has not done yet, but will be available soon.*

Concerning the question of who is in reality implementing the requirements and how are the priority areas defined, the interviewee from SRPA indicated that the activities are performed by SRPA, and the authorised expert organisation ZVD, but also some others, like Jozef Stefan Institute and ZAG. The national institute for public health is also collaborating in the awareness program.

Concerning challenges, the biggest challenge for SRPA are the capacities. SRPA has limited number of staff, knowledgeable in radon, and also has many other responsibilities (like then use of IR in medicine with related control). In addition, people are not so concerned about radon, connected risk and the health consequences. The proposed measures are not implemented (like ventilation). Small municipalities are less concerned; they do not have sufficient resources (also knowledge). Therefore, the SRPA staff is performing activities continuously and tries to inform the public as much as possible. SRPA also works with media. In 2018 they had seven interviews with journalists. The interviewee argued that it looks like there is no big concern within Ministry of Environment and Spatial planning , which would need to be involved.

The representative from the **Institute for occupational safety (ZVD)**, which is the authorised organisation for radon measurements according to the Atomic Act, indicated that for the requirements from legislation about involvement and participation of stakeholders the responsibility is with SRPA. However also ZVD is actively involved since it performs measurements on sites. Mainly, the role of ZVD is to perform measurements according to the adopted plan and available finances. In the last year 480 measurements were performed in the areas with increased radon, in the public buildings (like schools, kindergartens, other municipality buildings) and individual households. The employers are obliged to perform the measurements in relation to the doses for workers. ZVD provides expert advice on the measurements, distributes the detectors, analyses the measurements and prepares the report. This report is given then to SRPA who is responsible to inform and, in case of high radon concentration, requires the remediation. The remediation could include ventilation, limitation of presence in the room/building, request for building reconstruction or similar. ZVD performs measurements in houses (individuals), companies, public buildings. Based on the results and on the request from SRPA also measurements could be repeated after remediation.

The ZVD interviewee points out that there are different responses from involved entities. Representatives of companies (employers) sometime would like to hide that measurements are taken. The perception is that the employees perceive such measurements also as a possibility for additional benefits (like more vacation, higher incomes, benefits in working period,...). Some employees are really afraid, and some do not care. Therefore, the responsible in companies do not want that the information is given to workers. The relationship is directly between SRPA and the responsible which issues the ordinance with the information on the requirements (also in the relation to benefits or limitations for workers) and then also controls its implementation. Somehow different is the situation with school headmasters where many are very aware of indoor radon and themselves required the measurements via SRPA. They are under high pressure and are responsible for conditions for workers

and also for children/youngsters. Only few headmasters (approximately 1 in 40) would like to hide the results, basically because they do not understand the consequences. But the situation has improved very much.

According to the ZVD expert, the problems related to indoor radon are the following:

- Limitation of funds: The trend is positive and there is lately an increase in available resources, but still there are some limitations. The overall remediation takes from 1-2 years (from measurements, SRPA ordinance, the plan for remediation and its implementation, additional measurements, also in winter times). The challenge is that the municipalities need to pay by themselves and only **later can be reimbursed** by the state.
- Implementation of the remediation: depending on the results and requirements the implementation of remediation is a challenge. There are only **few qualified contractors** and there is **no training** and education on the level of state for this area. The municipalities have also the problem as they need to follow the **law on public procurement**, which is quite demanding (usually the lowest price applies which is paid at the end of works) and have problems with contracting the workers.
- Lack of coordination on the governmental level: the issue of indoor radon should be discussed and coordinated at the governmental level to be integrated in different remediations of public buildings. For example, if there is energy efficiency remediation, they should also look at the radon issue and perform the remediation integrally. But the responsible ministries are different and there is **lack of cooperation**.
- **Lack of awareness** in the public: some people are ignorant and do not want to know and care for radon. The change of mind set is very slow, although the trends are positive. With the new buildings the radon measurements will be obligatory and will need to be taken into account. But the guidelines for engineers, architects and constructors should be available also with the trainings.

3.1.5. Conclusions and recommendations

Legal requirements from the BSS directive are transposed into the national legislation. However, the responsible authorities are lacking the resources, especially human ones, to effectively perform control and provide the advices. The guidelines for new buildings are not yet adopted.

- ➔ The missing points need to be addressed and good approaches in other countries should be considered to improve the presence of the responsible authority in the public, and in particular to address the needs of more interested stakeholders (construction related companies, municipalities, responsible in schools and other public buildings, responsible in caves, ...).
- ➔ The government should assess the needs for new staff in the responsible institution to increase their presence in the public.

The awareness of public, and also small municipalities, about the risk posed by radon is relatively low and advices from the authorities are not followed (like regular ventilation of houses and similar).

- ➔ It is recommended that authorities (SRPA, Ministry of Health, National institute for public health) start nationwide awareness campaigns based on a communication plan where the radon topic would be presented alongside with most effective ways of reducing radon in buildings and elsewhere.

The interest in radon measurements is high especially in public buildings. The available funds are allocated by the principle that the first who requests is the first in line, and are limited. When the money is used, the requests are addressed in the next year.

- ➔ It is recommended to develop not just legal regulation for the national radon program, but also an action plan based on the evaluation of the situation and feedback from the current implementation.
- ➔ As the small municipalities have limited budget, the reimbursement policy from the state for radon remediation should be changed such that the costs are paid in advance.

Implementation of radon remediation is a challenge as the municipalities do not have sufficient knowledge, and there are also only few qualified contractors.

- ➔ The government should also provide the means for regular trainings for involved experts (staff at municipalities, engineers, architects, implementers) to be able to perform their duties.

At the governmental level the radon issue is not a priority, although the radon problem is within the responsibilities of several ministries: ministry for health with SRPA and National institute for public health, ministry for environment and spatial planning with construction regulation and inspections, ministry for infrastructure responsible for energy efficiency in public buildings, and also municipalities with responsibility in all public buildings.

- ➔ The government should establish a coordinating body where the radon topic would be effectively addressed.

3.3. Italy: Case study on the role of stakeholders in radon risk and prevention

3.3.1. Description of the case study

On the basis of Euratom Directive 2013/59 (see art 102) for the implementation of strategies for the management of existing exposure situations an appropriate coordination has to be ensured between the relevant parties involved in the implementation of remedial and protective measures and, as appropriate, the involvement of stakeholders in decisions regarding the development and implementation of the strategies. Moreover, (art 103) measures, including specific requirements in building codes, shall be in place to prevent radon ingress into new building.

In Italy the regulation regarding protection from radon exposure is stipulated by the Legislative Decree 241/2000 which refers to workplaces, including schools. This legislation commits the employers to proceed with the measurement of the annual average concentration of radon in certain types of workplaces, such as in underground places. A level of action of 500 Bq/m³ is indicated and above this level measures to reduce radon exposure of workers have to be implemented. No indication is given regarding houses, since the new Euratom Directive, indicating that the reference levels for annual average concentration of radon must not exceed 300 Bq/m³ for both homes and workplaces, has not been implemented yet officially at national level.

The Italian Ministry of Health prepared the Radon National Plan (PNR), highlighting that schools are priority settings, both because of the daily exposure of students, teachers, and administrative staff, as well as due to building-related characteristics. Such buildings are mainly at the ground level, and with construction materials inducing radon emission from walls and floor and even possible poor air ventilation. The PNR was launched three years later through the project ‘Start-up of the Radon National Plan for the reduction of lung cancer risk in Italy’, approved in 2005 and coordinated by Istituto Superiore di Sanità (ISS), and in collaboration with ISPRA (now ISIN) Istituto Superiore Prevenzione a Sicurezza Ricerca Ambientale, ISPESL (now INAIL) and the Regions as ARPA, and some Universities. A second phase of the project was launched in 2012 (<http://old.iss.it/radon/index.php?lang=1&id=192&tipo=15>).

As highlighted for example in the “Guideline for the prevention of exposures to radon gas in indoor environments, Lombardy Italian Region Decree 12678/2011”, over the years there is more and more attention to an approach that is not exclusively aimed at breaking down the higher values of radon concentration, but is oriented towards promoting interventions aimed also at the decrease of the medium/ low radon concentrations (taking into account the cost / benefit ratio), both through the application of prevention techniques in new buildings, and through remediation techniques on existing buildings. In addition to the public and interested citizens, this operative instrument involves the municipalities of the considered area, the designers and builders of buildings and other relevant professionals, at the decision-making level and on the technical choices.

The instrument of technical guidelines, the information documents addressed to the public, and the means of communication on radon risk at national and regional level, contribute to providing basic indications and views regarding the advantages of constructing radon-resistant buildings and proposals for actions to reduce radon exposure in existing buildings in synergy with the most common interventions aimed at energy-saving. As an example, radon concentration in Italian schools is also considered.

3.3.2 Objective and research questions

The objectives of this case study were to:

- evidence of the role and significance of different stakeholders’ involvement in radon risk information and prevention, with attention to indoor exposure.
- analyse which stakeholders are involved in an active way, their different levels of involvement, and the exchange of views and experience.
- observe, where relevant, the trends in relation to stakeholder involvement.

With attention to the objectives of this study the following questions have been considered.

1. What levels of awareness about external prescriptions of stakeholder engagement in relation to radon can be revealed?
2. How stakeholder engagement is understood and practiced stakeholder (at individual and institutional level)?
3. What were the rationales for stakeholder engagement, and it was implemented? Has there been a critical evaluation of the achievement of objectives and of the impact of stakeholder engagement? Have there been any guided improvement activities?
4. What forms of acceptance, resistance, denial, or alteration of engagement do you observe or encounter? And how do these forms change over time?
5. What are actors and communities, related to radon, doing that may *de facto* count as stakeholder engagement (but are not necessarily labelled that way)?
6. Are there any alignments/misalignments between case practice, on the one hand, and external conceptions and prescriptions, on the other, and if so why? Which challenges and opportunities do you encounter for stakeholder engagement in your specific case?
7. What are the benefits of implementing stakeholder engagement processes, in the situation studied?
8. What are the lessons learned for the establishment of efficient stakeholder engagement processes?

3.3.3 Methodology

Radon risk information and approaches to increase awareness have been analysed based on the following documents and websites:

- L. Vimercati, F. Fucilli, D.Cavone, L. De Maria, F. Birtolo, G.M. Ferri, L. Soleo, P. Lovreglio – Radon Levels in Indoor Environments of the University Hospitaò in Bari-Apulia Region Southers Italy. Int J Environ Res Public Health, 2018, 7; 15(4)
- Azara, M. Dettori, P. Castiglia, A. Piana, P. Durando, V. Parodi, G. Salis, L. Saderi, G. Sotgiu. Indoor Radon Exposure in Italian Schools. Int J Environ Res Public Health, 2018, 13; 15 (4)
- Ministero della Salute. Piano Nazionale Radon, 2002. <http://old.iss.it/binary/radon/cont/PNRtesto.pdf>
- Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro , ISPESL. Il radon in Italia: guida per il cittadino, 2007 http://www.salute.gov.it/imgs/C_17_opuscoliPoster_160_allegato.pdf

Interviews have also been conducted with attention to stakeholders such as involved professionals, for instance members of national/regional protection agencies and radon professionals related to schools and universities. This included one interview with a university professor dedicated to research projects on radon and another with the responsible for the radon question from a Regional Environmental Protection Agency (ARPA).

Attention was centred on the level of information and the perception of risk, as well as the idea of an ALARA approach to radiological protection concerning radon exposure, taking into account ethical and societal aspects in the practice for indoor exposure, rather than an exaggerated alarmism.

3.3.4 Analysis

A) Awareness and stakeholder involvement.

Different categories of stakeholders are recognized regarding radon risk, and with very different levels of awareness and involvement as evidenced in relation to particular cases.

Stakeholders are considered to include for example members of the public, workers and employers, and also building owners, industry professionals such as architects, geologists, builders, public bodies such as the municipalities that grant authorizations to build or renovate buildings, the former ASL and now ATS, the ARPAs as regional and national ISS bodies, and then the doctors, who should be stakeholders since radon is a health issue, and also family doctors who should be in the position to support families also in relation to radon exposures.

Users of the spaces or those directly involved are generally not very aware of radon issues. Awareness awakens sporadically, often in relation to journalistic articles and communication, and sometimes disproportionately with alarmism and without an adequate assessment of the actual situation.

With regard to private homes, attention to a possible radon risk is motivated essentially on a personal level. Radon risk is generally little known, and in any case an adequate importance is not given, as it is seen as a 'natural' element, therefore perceived as not dangerous.

Regarding professionals only some bodies and associations organize information and courses on the subject. Radon does not appear to be a topic covered by their basic professional training. In public institutions, the radon topic is more present, but there are difficulties in putting radon at a certain level of priority, as there are other problems that require attention and resources. The basis of distribution of resources with attention to risks is often done depending on the perception at the moment, more than on an evaluation; this makes that radon is not at the top of the list, both due to the low level of information, as well as the resources required by information campaigns.

Family physicians are often considered the great absentees, unable to support families when they are worried about their health with regard to radon and are faced with the problem. Training and refresher courses for doctors should take the radon issue into consideration.

B) Overview of the practice in stakeholder involvement

In practice there seems to be too much distance between the organizations with expertise and experience on radon, such as the ARPAs, and the public that is not aware of being able to turn to these bodies for support and information. At the same time, these organizations find themselves to have little staff on this issue.

A double thread can be recognized among regional and national resources dedicated to radon and the public attention to the possible risk related to radon. It is often reported that in practice certain needs are recognized as the result of pressure from stakeholders, including pressure from the public. Furthermore, the specificity of radon risk includes a double vision: radon risk is related to health effects, but does not refer to a medical exposure, which would be tackled through radiation protection in the health facilities. For this reason, even if radon is not strictly a problem of environmental quality, ARPA continues to deal with the health side of the radon problem.

In practice, in the case of radon in the workplace, the employee turns to the employer because she/he believes it is her/his right to work in a healthy environment, and therefore wants to get the employer to fight this problem. In the case of housing, often people do not want to face this problem, i.e. to recognise that it is dangerous to stay in your home. Additionally, there is also the economic side of remediation and the image of a house that can lose value. This makes that the issue of health can even become secondary. This is a mechanism that sometimes plays a role.

C) What emerged on the rationale of stakeholder involvement

From the interviews it emerged that in order to move towards an improvement of the initiatives undertaken, the de facto involvement of the population is desirable, and it is on this issue that the community of radiological protection is working. Furthermore, the experts interviewed considered that it would be useful to have a direct and greater involvement of the interested people, who represent the stakeholder who is in the building or in the house where there is a high level of radon. There is no legislation in Italy dedicated to housing, but, for example, as described by ISPESL, it should be remembered that the concentration of indoor night radon is higher than during the day, which is in fact the moment of greatest presence in homes. In this case it is up to the sensitivity of the individual to follow this theme, but there is a need to implement greater information and involvement. In this view, the initiatives taken at the regional level are aimed at focusing attention on radon in homes.

The Radon National Plan of 2002 considers a series of activities including training and information for the population and professionals in the concerned sectors. For example, the national initiative 'Environment and Health' of 2018, developed at regional level and generally addressed to professionals dealing with various issues of environment and health, has included training on radon together with other topics of interest, such as electromagnetic fields, air pollution, changes climate, waste, water and contaminated sites. However, it emerges from the interviews that much further progress is needed in the transition from programming to a real implementation. The national plan, which also reports actions aimed at reducing the population's exposure to radon, and which considers the involvement of stakeholders, has struggled to take off. It is hoped that with the transposition of Directive 2013/59 at national level, it will lead to greater participation, and a national coordination and concerted action, rather than action on the basis of singularly regional visions.

The Lombardy region with the participation of ARPA has drawn up a guideline that contains: - a part that concerns the legislation, - the measurement methods, and - a part dedicated to how we should design and restructure the buildings in order to reduce as much as possible (within ALARA) the presence of radon in buildings.

Alignment is also seen with respect to the application of these guidelines which the region has advocated that all municipalities should adopt them within the building regulations, and which required the ATS to stimulate their application at least in the building regulations. Opposite to this, there is evidence for misalignment between prescriptions and practice, as the transposition of these prescriptions is limited to a few municipalities. The reasons for this situation are other priorities, as well as the idea that when it will be time to review the building regulations, that will be the time to consider including this part as well.

D) Proposals and prospect for active improvement

The subject of 'environment and health' has received growing attention. The impact of environmental quality on health is subject to great discussion at national and regional level. This points out that radon has health relevance, it is a matter of health, and the fact that radon is inside buildings, it not due to the state of the environment that generates radon but the quality of buildings.

The question should be managed at long term and at the root, and in that view the young people represent an important stakeholder. If it is difficult to apply existing legislation, such as the national legislation on radon in the workplace and it is also difficult to apply a regional guideline, the aspect to be leveraged is the 'sensitivity of individuals', single stakeholders, who should require that construction of their own houses is adequate with respect to radon protection, and this can be done only if they know the problem and begin to give importance to this question.

This approach started with attention to information and training of young people, and professionals in general. attention to information and training of young people, and professionals in general, and students in communication have to be taken into consideration. Attention to youngsters is important to help people becoming involved .

Several campaigns to increase awareness of radon risk started in various regions, accompanied by conferences and information meetings in the evenings, to inform the public about ARPA's willingness to take measures and to make known the possible solutions in the event of high radon risk. This is in the process of development, for example between ARPA Lombardia and other entities interested to involve citizens on an individual level: "to capture the attention of the individual you must go and flush him/her out!"

Informing, training and sensitizing young people, regardless of whether the individual young person becomes a family doctor, goes to work in municipality offices, or becomes a designer or other, she/he has been trained as a person and will be a future stakeholder in various forms, and will have a priori knowledge of the various aspects of radon risk.

3.3.5 Conclusions and recommendations

- There is more attention to the radon issue in the buildings for workers, than in dwellings. In the case of private houses, people often do not want to face this problem, i.e. to recognise that it is dangerous to stay in their home; additionally, there is also the economic side and the image of a house that can lose value.

- Radon has health relevance, and it is not the state of the environment that generates increased radon risk, but the characteristics and quality of buildings. It has to be considered who is in charge regarding the possible high radon exposure for the public: health care institutions or environmental institutions?
- In order to render involvement effective, connections are needed closer to the population and to the local actors, such as municipalities or schools, which are considered as an important help.
- The need for individual involvement is highlighted by actors interviewed, who point out that policies imposed from above are sometimes put into practice, while other times this approach does not work. Risk management structures that favour the connection with, and involvement of, the public are today considered as a good point in practice.
- Informing, training and sensitizing young people, regardless of whether the individual young person becomes a family doctor, goes to work in municipality offices, or becomes a designer or other, she/he has been trained as a person and will be a future stakeholder in various forms, and will have a priori knowledge of the various aspects of radon risk.

3.4. Cross national study: Analysis of radon websites from a stakeholder engagement perspective

This section summarises the analysis of radon websites in eight European countries from a stakeholder engagement perspective. A detailed description and analysis of this case study can be found in *Perko T. and Turcanu C. (2019). Is internet a Missed Opportunity? Evaluating Radon Websites from a Stakeholder Engagement Perspective* (submitted for publication).

3.4.1 Description of the case study

Exposure to indoor radon in homes is one of the main causes of lung cancer worldwide. However, the levels of radon testing and subsequent home remediation remain lower than aimed for by radon National Action Plans in European countries. Recent studies suggest that public engagement may contribute to addressing this value-action gap.

3.4.2 Objectives

Radon websites serve as a common interaction points between citizens and public services. This research aimed at analysing national and local authorities' radon websites from a stakeholder engagement perspective.

3.4.3 Methodology

173 websites of national, regional and local authorities responsible for radon issues have been evaluated in eight European Union countries. This included national authorities responsible for the radon communication plan according to new the BSS directive (e.g. nuclear safety authority or ministry of health), as well as to regional and local authorities (e.g. municipality websites of communities in radon prone areas). The aim was to include all the relevant websites at national level for each country. In addition, depending on the different administrative contexts in each country at regional and local level, we selected a random sample of relevant websites. Case studies were selected from European Union Member States, in light of the revised European legal requirements (Basic Safety Standards – BSS) stipulating the implementation of national radon communication programs. The selection of the

European Member States for analysis took into account the surface of high radon prone areas and the numbers of population at risk from indoor radon: Belgium, Croatia, France, Germany, Italy, Ireland, Slovenia and Spain.

The website evaluation metrics included indicators related to availability of radon information, accessibility, stakeholder interaction, dialogue, responsiveness, content and design, and transparency and openness.

3.4.4 Analysis

Results show that availability of radon information on the internet of radon prone areas is limited. Websites containing radon information should be improved with consistent information supported by engaging stories, provide for personalized features, allow for stakeholder feedback and dialogue, and include the use of social media. The analysis is concluded with a synthesis of good practices, see table below.

Engagement factors	Good practice for stakeholder engagement in radon issues identified
Availability of radon information on internet	<ul style="list-style-type: none"> • Webpages of national and local authorities include radon related topics. • A special, dedicated radon internet page is developed at national level. • The internet page of the local community has a special radon sub-page. • Radon information is clearly identified and all information is collected on one sub-page. • The internet page includes outreach documents, such as brochures. • National and local radon webpages are cross-linked.
Accessibility	<ul style="list-style-type: none"> • The design of the webpage is adapted to different mobile applications and devices (e.g. computer, smartphone). • Personalized and customizable features are included on the webpage (e.g. GPS coordinates linked to radon prone areas, interactive radon map, radon concentrations included on the map). • All links mentioned in the webpage are functional and tested regularly.
Stakeholder interaction	<ul style="list-style-type: none"> • Feedback forms and satisfaction questionnaire are included in webpages. • Tools designed for collecting stakeholder questions and answers are on-line and open to all stakeholders, not only to residents. • A stakeholder can follow radon-related discussions by broadcastings and can participate in Webinars related to radon. • Information for direct personal communication about radon is available and inviting. • New social media are integrated and encourage enhanced stakeholder engagement in radon issues (e.g. Facebook, Twitter, YouTube).

Engagement factors	Good practice for stakeholder engagement in radon issues identified
Dialogue	<ul style="list-style-type: none"> • Chat areas and message boards are open to everybody and the content is visible to everybody. • A stakeholder can register for email updates, newsletters etc.
Responsiveness	<ul style="list-style-type: none"> • E-mail addresses published on-line are functional, and there is a person that responds to the stakeholders' questions. • Response to an email is given in a reasonable time, it contains factual information and addresses risk perception and empathy, if appropriate. • Response is taken as an opportunity to engage.
Content for different stakeholders groups	<ul style="list-style-type: none"> • The organizational structure of the webpage is clear and easy-to-use. • The webpage is user orientated and user-friendly. • The webpage story is clearly structured around radon issues. • The content is personalized and includes greetings for radon stakeholder. • Different stakeholder groups have special sub-pages and designed content. • Webpage is easy to learn. • Basic radon information is easy to find: where to get self-radon test, how much the kit cost, where will be results published.
Transparency and openness	<ul style="list-style-type: none"> • The radon action plan is published online. • Radon subventions and applications are published online. • Tenders for radon mitigation activities are published online. • Financial documents related to radon action plan are published online. • The new Basic Safety Standards Directive is published on the webpage. • National legislative documents directly or indirectly linked to the radon issues are easy to find. • Radon mapping activities and plans are easy to find and follow. • Mitigation activities are regularly and transparently reported.

3.4.5 Conclusions

This research showed that internet is insufficiently used to empower stakeholders to be involved in decision-making related to radon risks in radon prone areas, or to make informed decisions related to radon risk reduction. However, there are some good practices that authorities could follow.

4. Round table at the Radiation Protection Week 2018

A round table was held in the framework of the ENGAGE project at the 3rd Radiation Protection Week on 2nd of October 2018, to discuss stakeholder engagement in relation to exposures to indoor radon. Participants were invited to share their experiences, recommendations on best practice and views on challenges ahead. The topics for the moderated discussion at the round table include radon awareness, the role of stakeholders in radon action plans, and the engagement of stakeholders in decision-making and implementation of mitigation actions. Participants included radiations safety authorities, academics and research organisations (Abelshausen et al, 2018).

The participants at the round table indicated that issues concerning indoor exposure to radon have in the past been proven difficult to place high on policy agendas. Radon health risks from indoor exposure were not considered as a public health issue; since the revised Basic Safety Standards this is (gradually) changing as all European Member States have to develop and implement radon action plans. These plans, and the past and current implementation practices, are not without difficulties. For example, due to the heterogeneity of radon exposure, mapping radon prone areas is challenging. Additionally, even when implementation challenges are tackled, only a small fraction of the population carries out measurements or applies remediation measures. It is deemed necessary to involve stakeholders not only to develop the plans and implement them, but also to engage affected populations in applying protective measures.

Participants showed that engagement in practice presents itself in various forms: provision of information, gathering of feedback from local communities on action plans, organisation of workshops, communication at school level, joint inspections, public meetings, self-test for radon. It should be noted that stakeholders have expressed an interest to aid responsible governments in the development and implementation of action plans, but a structured and formalised manner to engage them does not exist. Several hesitations by various stakeholders also exist; local authorities for example may experience a fear of panic among affected populations, and affected populations may not be interested or have specific concerns, for example related to the cost of mitigating actions or lower value of estate.

A key stakeholder involved in mitigating indoor exposure to radon is the building industry. In practice, this engagement translates itself in legislation or prescriptions in building regulations that houses should comply with respect to radon. In a more informal manner this engagement includes the obligation to inform potential clients about radon concentrations before selling a private house. Additionally, several countries indicate the need for (or existence of) categorisation according to the potential for exposure and an implementation of corresponding measures. Furthermore, local authorities are considered as a key stakeholder as they possess particular knowledge they can bring into the process. Some participants pointed out the importance of local initiatives and argued that national campaigns may be less effective than campaigns at local level.

Besides the aforementioned challenges, participants also bring forth opportunities for stakeholder engagement and protective actions against radon exposure. These opportunities include for example, citizen science, commercialisation of radon tests, reducing costs or provision of test by non-governmental organisation. Concerning public spaces however these opportunities do not apply and the responsibility remains with the authorities.

In general it can be concluded that opportunities for stakeholder engagement exist in mitigating indoor exposure to radon. Stakeholder engagement is however complex and hesitation exists for several key stakeholders. Thus far, both formal and more informal forms of engagement exist; all experiencing opportunities and challenges. Emergent forms of engagement such as citizen science are however

brought forward as practices with great potential to improve mitigation of indoor radon exposure. More research is needed to elucidate whether and how this potential is confirmed in practice.

5. Conclusion

Radon is a public health problem, as much as it is an environmental problem, an economic problem, and an urbanism / building problem, which means in practice there are many fields of responsibility, both public and private.

The case studies provide evidence that radon risk management poses several challenges: **plurality of responsibilities** spread among authorities that may have different objectives and different approaches to risk assessment, **lack of awareness** about radon and its risk among the general public as well as among key professional stakeholders (e.g. family doctors, architects, building professionals), **disparities of knowledge** (greater awareness of radon in highest radon risk areas compared to other areas), **economic impacts** (cost of remediation actions, as well as the potentially lower value of estate), and a **value-action gap** in what concerns the connection between risk awareness and initiation of actions for radon measurement and remediation, even in the presence of subsidies. These challenges give indications about the stakeholders that should be engaged in radon mitigation and the associated participatory actions needed.

Various categories of stakeholders are recognised, including members of the public; workers and employers; building owners; radiation safety authorities; radon experts; industry professionals such as architects, geologists, builders, public bodies at national, regional, provincial and local level responsible for radiation protection, health and environment, urbanism and planning, including energy saving policies; organisations or companies implementing radon measurement and/or remediation actions; family doctors.

The Belgian case study showed the complexity of the **distribution of responsibilities and tasks** between the different authorities that play a role in radon risk management: radiation protection, public health, environment, urbanism. The adoption of an **integrated approach** of radon as an environment-health issue (related to indoor air quality) together with urban planning and energy saving policies would favour the involvement of citizens and the adoption of protective measures.

It also provided evidence for the **need of a strategy for global communication** about risk assessment and management, which should integrate all responsible authorities and at all levels of governance: national, regional and local. In particular, it showed that while interactive maps are very useful tools for raising awareness by showing where the risk is above average, they might be misleading for local actors. This categorisation may demobilize population living in an area that is not referred to as a high risk zone on the map and may convey the idea that radon risk is in a local zone, while the experience shows the contrary. Additionally, the scale of the map is too large to define the risk accurately. This substantiates the importance of not restricting the actions only to radon prone areas and to adapt building techniques all over the country, in order to impact the lung cancer incidence rate.

The Slovenian case study highlighted challenges in the implementation of legal requirements in practice, due to **lack of resources (human and financial) and appropriate organisation** with involvement of all levels of public authorities to effectively perform control and provide remediation advice. It also suggested that in order to make radon a priority, the government should establish a coordinating body where the radon topic would be effectively addressed.

The Italian case study reveals that the topic of radon is not covered by basic professional training. While there is more attention to radon in public institutions, it is not always considered a priority, both

due to the low level of information and the resources required by information campaigns. This case study also highlights the importance of informing, training and sensitizing young people.

In general, awareness of external prescriptions for stakeholder engagement is low. However, cases suggest that, due to lessons learned from previous experience (low awareness, low level of application of remediation actions,), there is a general trend towards broadening engagement, both with respect to stakeholders, as well as the level of engagement. Participatory actions carried out, allowing for increased interaction and engagement, include local meetings in the evenings in municipalities with high radon risk, public conferences, focus groups, organisation of workshops, gathering of feedback from local communities on action plans, joint inspections, self-tests for radon, among others. However, there is in general no structured approach to stakeholder engagement in the design, implementation and evaluation of radon action plans. Other opportunities for engagement also exist, for example, citizen science, commercialisation of radon tests, reducing costs or provision of test by a non-governmental organisation.

Actions supporting citizens' engagement that are currently being carried out in the countries studied are two-way communication (see e.g. the cross national website analysis for good practices) e.g. through websites, free newspapers, or social networks; training of professionals, authorities, school children, medical doctors; support (including subsidies) for measurement and remediation, with the possibility of asking for a radon detector on-line at any time (thus not only during a measurement campaign); and unaddressed post-delivery to all houses in the target municipality with the support of the local authorities.

The cross national case study showed that internet is insufficiently used to empower stakeholders to be involved in decision-making related to radon risks in radon prone areas, or to make informed decisions related to radon risk reduction. However, there are some good practices that authorities could follow.

Both the Belgian and the Italian case studies highlight that the top down approach has not been effective for private houses. In Italy, there seems to be too much distance between the organizations with expertise and experience on radon and the public that is not aware of being able to turn to these bodies for support and information; at the same time, these organizations find themselves to have little staff on this issue. The utility of risk assessment might be increased by clearly linking it to context sensitive risk-management options, in order to inform the decisions of those in charge of risk mitigation about the available options. At the same time, engagement of local partners (local municipalities, schools) and members of the public may facilitate implementation of radon mitigation actions in private houses and is considered a good practice.

Finally, the results indicated that that action oriented research (e.g. though citizen science) with case studies is necessary to better understand the interactions between stakeholders engaged in different policy issues and / or at different levels of responsibility in a web of multiple frames and constraints.

6. References

Abelshausen, B., Turcanu, C., Perko, T., & Polz-Viol, C. (2018). Round table on stakeholder engagement in relation to radon exposures. www.engage-concert.eu

WHO. (2009). WHO handbook on indoor radon: a public health perspective; Edited by H. Zeeb, and F. Shannoun, 94 p.

Annex 1 Additional information for the Slovenian case study

In the Slovene Atomic Act implementing the national radon programme the following is requested:

- The authority competent for nuclear safety shall, through systematic monitoring and measuring of radon, dose rate and other suitable indicators, ensure the identification of:
 - exposure due to radon in facilities used for carrying out childcare, education, cultural or health care programmes;
 - exposure due to radon in living environments in a basement or ground floor, or in other areas where it can be expected the average annual radon concentration exceed the reference levels;
 - external exposure in indoor areas in existing buildings because of the building materials used;
 - exposure due to radon in cases where a higher radon concentration is expected such as spas, caves, mines and other underground areas.
- Measurements under the preceding paragraph shall be conducted by experts who shall be authorized to take such measurements.
- The employer shall ensure the radon in working environments on ground levels and in basements in an area with more radon is measured within three years of the declaration being made that the area contains more radon. The employer shall provide measurements whenever the situation affecting the radon concentration significantly changed (for example larger building projects).
- The employer shall ensure the radon in working environments throughout the Republic of Slovenia at locations where increased radon concentration can be expected, such as in spas, pools and other radon water sources, caves, mines and other underground working environments, is measured.
- If, based on the systematic radon measurements at workplaces, it is determined that the average annual radon concentrations exceed the reference levels (set to 300 Bq/m³ average annual concentration), it is necessary to assess the exposure of workers and population.
- Exposure shall be assessed by authorized operators for radon measurements and the assessment shall be performed by the taxpayer for the provision of measurements.
- The exposure assessment of workers shall include a statement on safety with risk assessment in accordance with regulations on health and safety at work.
- If the exposure assessment shows that people in public buildings or workers at workplace due to radon exposure receive the annual effective dose that is higher than 6 mSv, it is necessary to implement measures to reduce the exposure such as ventilation, relocation of people to other areas, the cessation of use of premises and building interventions, if it is assessed that building operations will adequately contribute to reducing exposures, and comparable results cannot be achieved by other simpler measures. Measures to reduce exposure of workers can also be a re-organisation of tasks and working hours.
- If the exposure assessment shows that despite exceeding the levels for the average annual radon concentration, people in public buildings or workers at workplaces receive the annual effective dose which is less than 6 mSv, the measures under the preceding paragraph shall not be necessary but the conditions affecting the exposure must be monitored and the dose reassessed when changes occur.
- Carrying out measures for workers shall be provided by their employer and for the public exposed in public buildings by the holder of the activity in such a building.
- The effectiveness of implemented measures shall be verified by repeating measurements in 6 months after introducing the measures or after completing building. Measurements are

provided by the person obligated to ensure measurements under the preceding two paragraphs and are carried out by the authorized provider of radon measurements.

- If children, adolescents, patients or other sensitive groups of the population due to radon exposure receive the annual effective dose that is greater than 6 mSv in facilities used for the childcare, education, cultural or health care programmes, the resources for implementing measures for reducing exposure shall be provided by the State.
- If despite implementing the measures workers receive the annual effective dose due to radon exposure which is higher than 6 mSv, the authority competent for radiation safety shall order the employer to implement measures for radiation protection of exposed workers by applying, inter alia, the provisions of this Act that refer to the protection of exposed workers during carrying out a radiation practice.
- New buildings for living or working environments shall be planned and constructed so that the radon concentrations do not exceed the reference level.
- Interventions in an existing facility that could affect radon concentration in a building (for example energy building rehabilitation) shall be planned and carried out so that the intervention in the building will not require measures to be taken on reducing radon concentrations to protect people's health.
- The minister competent for building and the minister competent for health shall prescribe the requirements for new buildings and rebuilding of buildings by which the health of people is protected against harmful radon effects.

In addition, the government shall:

- adopt a national radon programme on managing long-term health risks due to radon exposure;
- The authority competent for radiation protection shall regularly check the implementation of the national radon programme, evaluate radon measurements taken and doses received due to radon exposure, and report about it in the annual plan on ionising radiation protection and nuclear safety,
- The Government shall adopt the national radon programme for a period of 10 years. Before the national radon programme expires the Government shall evaluate the implementation of the programme and prepare proposals for further optimisation of radiation protective measures and for reducing radon exposure.

The government shall adopt a national radon program in which also a separate program to raise awareness among employers, the public and health professionals about the health risks posed by radon exposure, and the additional risks associated with smoking is part. This shall also include the importance of carrying out measurements of radon and measures to reduce exposure. The program shall be developed for period of 10 years and every new revision shall include also the assessment how well the previous one was implemented.