



NRCS

National Radon Control Strategy
Straitéis Náisiúnta um Rialú Radóin

National Radon Control Strategy

Knowledge Gaps Phase 2

2019 - 2024

National Radon Control Strategy – Knowledge Gaps

Phase Two: 2019-2024

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1. Background

Radon is a radioactive gas formed in the ground by the radioactive decay of uranium which is present in all rocks and soils. It is the greatest source of exposure to ionising radiation for the public in Ireland and the leading cause of lung cancer after smoking. It is estimated that exposure to radon accounts for approximately 300 lung cancer cases each year.

Recognising the scale of the radon problem in Ireland, the Government published Phase One of the [National Radon Control Strategy](#) (NRCS) [1] in February 2014. A knowledge gaps paper that identified areas where targeted research could support and improve the effectiveness of the NRCS was also published. The achievements of Phase 1 of the NRCS and supporting research can be found in the reports: “National Radon Control Strategy – Final Report to Government” [2] and “Review of Knowledge Gaps paper 2014 – 2018”[3].

While significant progress was made during Phase 1 of the NRCS, radon continues to be the greatest source of radiation exposure to the public. To continue to address this, it is important that the actions implemented during Phase 1 are maintained, that the research needed to support the implementation of these actions continues and that the learnings from implementing Phase One are built upon. In this way, work to minimise exposure to radon gas for people in Ireland and ultimately to reduce the incidence of radon related lung cancers will continue. Phase 2 of the NRCS [4] sets out a range of measures under 5 thematic areas. Again, knowledge gaps exist that may inhibit effective delivery of the NRCS. The key gaps and the proposed research to support actions in Phase 2 of the NRCS are identified in this paper.

To address knowledge gaps identified during phase 1 of the NRCS, funding from a range of sources including government departments and agencies was availed of. It is envisaged that a similar funding mechanisms may be availed of to address the knowledge gaps identified for phase 2 of the NRCS. The EPA research programme or co-funding opportunities are other funding options that may be availed of.

2. Identifying knowledge gaps

Knowledge gaps to be considered over Phase 2 of the NRCS were identified following:

- (a) The review of Knowledge Gaps paper 2014 – 2018 [3]
- (b) Consultation with the NRCS Co-ordination Group
- (c) Consultation with the radon research community in Ireland

(a) The review of the Knowledge Gaps paper 2014 – 2018

A review of the Knowledge Gaps paper 2014 – 2018 [3] was carried out by the EPA in September 2018. A summary of the key issues identified following this review are outlined below:

Key issues identified following the review of the Phase 1 Knowledge gaps paper

- Work to validate and review the refined radon risk map is currently being carried out by the EPA. Once this is complete, the next step will be to establish how the new map will replace the existing map, assessing the implications of the new map on public awareness and radon policy and communicating the change.
- Future revisions of Technical Guidance Document C (TGD-C) are an important opportunity to include the outcome of research carried out on radon prevention in new buildings.
- Research regarding the effectiveness of passive radon sumps and the conversion of standby sumps to passive sumps will be important to inform the next revision of TGD-C.
- As energy efficiency in homes improves and air tightness increases, the effect these measures have on indoor radon levels should be considered over the coming years.
- The use of behavioural science to better understand the outcome of a survey to establish funded testing and remediation rates may be used to feed into the development of any future national grant.
- Research to assess building materials for radioactive content (including radon) to determine whether they are appropriate for use in construction is required.
- Areas with anomalously high radon levels, notably around Tralee and Castleisland in north Kerry, that are associated with karstified limestone and other areas with similar geology need further investigation.

(b) Consultation with NRCS co-ordination group

A meeting of the NRCS co-ordination group meeting took place on 5th December 2018. The EPA presented the key achievements and emerging issues from the review of the Knowledge Gaps 2014 – 2018 paper. Following the meeting, feedback on the paper was sought from the NRCS co-ordination group members. This feedback is summarised in Appendix 2.

(c) Consultation with the radon research community in Ireland

An EPA facilitated workshop to set radiation research priorities for Ireland and to begin developing a radiation research roadmap was held on 21st November 2018. The workshop was attended by approximately 50 researchers involved in the radiation research field in Ireland. A summary of the research topics identified at the workshop can be found in Appendix 1.

The feedback from these three strands was then used to point to areas where targeted research could support and improve the effectiveness of the actions outlined in phase 2 of the NRCS. The knowledge gaps have been divided into three thematic areas and sub topics identified under each theme. All knowledge gaps identified are listed in Appendix 1 and prioritised as high, medium or low priority,

3. Knowledge gaps to be addressed in Phase 2 of the NRCS

Research Theme 1: Improving the effectiveness of radon preventive measures and radon remedial work

- (a) Effectiveness of passive prevention systems in new builds
- (b) Possible modifications of existing standby sump systems
- (c) Use of new construction technologies to reduce radon
- (d) Improvements in remediation systems
- (e) Contribution by building materials to indoor radon levels

(a) Effectiveness of passive prevention systems in new builds

There is strong evidence both internationally and in Ireland that the correct installation of passive prevention systems in new buildings is the most cost effective way of protecting the population against radon [6,7,8,9]. Technical Guidance Document–C, which sets out the radon preventive measures required under the 1997 amending Building Regulations, requires that all new homes built since July 1998 are fitted with a standby radon sump which can be

activated at a later stage, to reduce high radon concentrations subsequently found [10]. For homes built in High Radon Areas (HRA), the installation of a radon membrane as well as a standby sump is required. In 2015, the EPA established that the geographic weighted national average radon concentration was 77 Bq/m³ [11]. This represents a 13% reduction since this metric was first established in 2002 [12] and the reduction can be attributed to the introduction of the 1997 Building Regulations.

However, there is evidence that suggests the continued installation of standby sumps is not cost effective because of the very small proportion that are subsequently converted into active sumps [7]. Recent research has shown that the installation of passive sumps as a preventive measure may provide a reduction in radon levels in new homes. Public Health England (PHE) has shown that the use of passive sumps can reduce radon levels by approximately 33% [13]. The reduction in radon levels using passive sumps observed by PHE indicates that there would be immediate and ongoing benefit to the occupiers of new homes and associated costs to the builder would be potentially low. A literature review of the effectiveness of passive prevention systems should be carried out and should investigate whether there is potential to include the requirement that all new homes are installed with a passive radon sump as a complementary preventive measure to the installation of a radon membrane.

An EPA funded three-year study investigating passive prevention systems is currently being carried out by the National University of Ireland, Galway. The aim of the study is to identify the optimum specifications to prevent entry of radon by considering the membranes, modern hardcore and sump system employed in homes in Ireland. The study is due to be completed in 2019 and experimental work to establish the effectiveness of passive sumps is underway at present. Initial findings show promising results and suggest a potential reduction in the national average radon concentration if a passive sump was installed in all new homes. To validate these findings, field studies to establish the effectiveness of passive sumps should be carried out. A review of studies on the effectiveness of passive prevention systems such as should then feed into the next revision of TGD-C.

The Department of Education have for many years installed a radon membrane in all newly built schools irrespective of whether a school is in a HRA. More recently they have begun installing passive sump systems routinely. Radon measurements are carried out in all newly built schools. The effectiveness of the combination of a passive sump and a radon membrane in schools in Ireland is unknown. This data could be used to assess the effectiveness of passive prevention systems in schools in Ireland.

- A literature review of research into the effectiveness of passive prevention systems should be carried out so that the findings can be used to inform the next revision of Technical Guidance Document C.
- Installation of passive sumps have been shown to reduce radon concentrations in new builds. Field studies to estimate the reductions in radon levels that can be achieved in Irish homes using passive sumps should be carried out.
- The effectiveness of passive prevention systems in schools in Ireland could be assessed using data from newly built schools.

(b) Possible modifications of existing standby sump systems

Since the introduction of Building Regulations in 1998 requiring radon preventive measures, there has been a significant increase in the number of homes built. Figures from the Department of Housing Planning and Local Government [14] estimate that the housing stock in Ireland increased from 1.366 million units in 1999 to 2.018 million units in 2017, a growth of approximately 32% in the national housing stock. This would suggest that there may be over 650,000 homes in Ireland that have been built with standby sumps installed. Converting these standby sumps into passive sumps could reduce radon concentrations in these existing homes. However, estimates of the reductions in radon levels that may be achieved by converting standby sumps in existing homes as well as the feasibility of converting them is unknown.

- Based on the results of the NUIG research investigating the potential reduction in radon levels achieved by passive sumps in new builds, the effectiveness and feasibility of converting standby sumps in existing homes into passive sumps should be considered.

(c) Use of new construction technologies to reduce radon

As changes in construction technologies occur, the impact of these changes on radon levels should be considered. A driver for construction technologies to change over the coming years is the energy performance in buildings directive (EPBD) [15] that mandates all EU member states to build near zero energy buildings [16] by 2021. Research is currently being carried out on radon levels and indoor air quality in Northern Ireland passive home buildings by Queens University Belfast. Initial findings suggest that homes built to the passive house standard correspond with lower radon concentrations.

For existing homes, the implications of deep energy-efficient retrofits on indoor radon concentrations is unknown. NUIG are currently investigating how a number of indoor air pollutants including radon and occupant comfort will change post deep energy renovations in domestic Irish dwellings. Further research on energy retrofit is a topic that could be considered should demand for this type retrofit increase over the lifetime of the NRCS.

- Continue to support research on the effect of emerging construction and retro fit technologies on indoor radon levels

(d) Improvements in remediation systems

A knowledge gap identified in Phase 1 of the NRCS was to investigate the optimum power and positioning of the radon fan used in active radon systems. This knowledge gap was not addressed in Phase 1 of the NRCS and has been carried forward to Phase 2. The outcome of research by NUIG regarding the effectiveness of passive sumps and future work to investigate the effectiveness and feasibility of converting standby sumps to passive sumps from the NUIG study investigating radon mitigation techniques should be prioritised before investigating optimum fan power and position on sumps systems.

- What is the optimum fan power that should be used in active radon sump systems and what is the optimum positioning of radon fan exhausts on buildings being remediated?

(e) Contribution by building materials to indoor radon levels

Assessment of building materials for radioactive content can be used to decide if they are appropriate for use in construction. In addition to this topic being identified as a knowledge gap for the NRCS, The Ionising Radiation Regulations 2019 [17] set a national reference level applying to external exposure to gamma radiation emitted by building materials of 1 mSv per year and states that building materials shall be identified that, in terms of the emitted gamma radiation, may be of concern from a radiation protection point of view.

- Radon originates from the ground, however there is the possibility that building materials could also contribute to high radon levels. The contribution made by building materials to indoor radon levels should be established.

Research Theme 2: Better targeting of measures and resources

- (a) Implications of adopting a new radon risk map
- (b) Reviewing and updating the map

- (c) Investigating the effect of different behaviourally informed communications on radon testing and remediation rates
- (d) Tracking the effectiveness of the National Radon Control Strategy through metrics

(a) Implications of adopting a new radon risk map

In 2017 the Geological Survey of Ireland (GSI) and Irish Research Council (IRC) funded research to develop a logistic regression model to detect radon prone areas in Ireland. Using this model, Trinity College Dublin (TCD) developed a new high spatial resolution radon risk map of Ireland based on a combination of approximately 32,000 geocoded indoor radon measurements and bedrock geology, soil geology, soil permeability and aquifer type [18]. In 2017, TCD carried out work to validate the indoor radon risk map of Ireland. This validation work was funded by the GSI [19].

The EPA is carrying out an independent validation of this significantly refined radon risk map in collaboration with researchers from TCD. It is envisaged that ultimately this map will replace the existing map. When the validation work has been completed, the next step will be to establish how the new map can support radon policy and decision makers and how it can be used as a public communication tool. Aspects to be considered include:

- Completion and documentation of the EPA validation of the TCD map
- Determine the implications of the new map on radon policy including Building Standards and radon risk assessment
- Establish the new map as a communication tool for policy makers, stakeholders and the public

(b) Reviewing and updating the map

Recognising that the adoption of an improved radon risk map is a key achievement, an important next step is to ensure that it is updated as new data becomes available. New data that may be included includes TELLUS survey data [5], updated bedrock maps, new radon measurement data and the identification and investigation of areas with anomalously high radon levels.

Areas with anomalously high radon levels associated with karstified limestone areas can be found in Ireland, notably around Tralee and Castleisland in north Kerry. Studies in these areas and in other areas with similar geology may refine the risk map by identifying areas where homes are at risk of anomalously high radon levels.

- A programme and procedure for updating the radon risk map should be developed to ensure the map remains current. This should take account of the implications of changing the radon risk map as set out in (a).

- The radon risk map could be improved by carrying out research in areas with anomalously high radon levels that are associated with karstified limestone.

(c) Investigating the effect of different behaviourally informed communications on radon testing and remediation rates

Phase 1 of the National Radon Control Strategy for Ireland recommended that consideration be given to the introduction of financial incentives to encourage radon testing and remediation. Furthermore, the review of the EPA’s awareness campaigns highlighted the need for financial incentives to achieve behavioural change and increase the rate of testing and remediation [20]. The Department of Communications, Climate Action and Environment provided funding to the EPA to carry out a research survey to establish the rates of radon testing when financial incentives are provided. The survey offered participants a free radon test and a grant of 50% of the cost of remediation (up to a maximum of €500) if their radon level was above the reference level of 200 Bq/m³. The results of the survey would then be used to inform the design of a national financial incentive scheme, which may be provided for in future legislation.

The response rate to the survey was 20% and is a similar response rate to that seen in previous EPA surveys offering free radon tests to participants [11,12,21]. A higher response rate was expected for this survey as it offered both a free radon test and a grant towards the cost of remediation to participants.

Under the EPA/Economic and Social Research Institute (ESRI) research programme, the ESRI have noted that there may be novel approaches that could improve public engagement with offers of radon tests and grant applications for households with high radon measurements that have yet to be trialled. Moreover, there may be scope in this area for controlled laboratory or online experiments to test the best ways to communicate to householders the risks of radon. As outlined in the review of the EPA’s awareness campaigns [20], it may be important for communications to target the initial information processing features of the decision to remediate radon.

- Carry out behavioural research trials with the ESRI to test different communications and/or financial incentives and assess their impact on radon testing and remediation rates.

(d) Tracking the effectiveness of the National Radon Control Strategy through metrics

The overall objective of the NRCS is to “minimise the exposure to radon gas for people in Ireland and to reduce to the greatest extent practicable the incidence of radon related lung cancers”. To measure progress towards this goal, a set of metrics and timeframe for updating

these metrics was agreed by the NRCS Coordination Group and research to update NRCS metrics will be required periodically [2]. Details of the NRCS metrics can be found in the NRCS Phase 2 report.

- Research to update the NRCS metrics should be carried out as set out in the NRCS Phase 2.
- A programme of reviewing the appropriateness of current NRCS metrics and the frequency at which they are updated should be developed. New metrics should be considered as they arise and included in the programme.
- Modelling work to estimate target values for NRCS metrics could be investigated, particularly for the population weighted average which is a key metric required to estimate the number of radon related lung cancers.

Research Theme 3: Developing radon risk communication and raising awareness

- (a) Establishing baseline awareness levels amongst solicitors, estate agents and surveyors
- (b) Updating communication literature based on the outcome of behavioural research trials
- (c) Radon awareness in patients of a rapid lung access lung cancer clinic

(a) Establishing baseline awareness levels amongst solicitors, estate agents and surveyors

One of the key achievements delivered under Phase 1 of the NRCS was the inclusion of three questions on radon in the conveyancing process. Since 2017, it has been a requirement when a second-hand house is being sold for the sellers' solicitor to ask the following questions:

- (1) Has a radon test been carried out?
- (2) If a radon test has been carried out, please supply the report.
- (3) Has any action to reduce radon levels been undertaken?

This information is then passed on to the buyer's solicitor. If the buyer has any concerns their solicitor will advise that they get expert advice. At present, there is no data on the impact that this requirement has had on radon testing, nor is there any data about whether the stakeholders (homes buyers, sellers, solicitors and estate agents) are aware of this requirement. Solicitors, surveyors, landlords and new home owners are key influencers if property transactions are to be used as drivers for action on radon. The level of awareness amongst these groups is unknown.

- An assessment of the baseline level of awareness of radon among solicitors, surveyors, landlords and new home owners is required.
- Once baseline levels of awareness have been established, a programme of awareness targeting these groups should be carried out and awareness levels then re-measured.

(b) Updating communication literature based on the outcome of behavioural research trials

Based on the outcome of the EPA/ESRI controlled laboratory or online experiments to test the best ways to communicate to householders the risks of radon, all EPA radon related communication materials should be reviewed to take account of the findings and ensure that these materials are re-designed to encourage behavioural change and ensure a consistent message is delivered.

- Review and update EPA radon communications to incorporate the findings of the EPA/ESRI research

(c) Radon awareness in patients of a rapid lung access lung cancer clinic

A specific study of radon awareness and radon action amongst patients at a rapid access lung cancer clinic found that only 5% of the patients were aware of the link between radon and lung cancer. This points to an opportunity to improve awareness amongst certain sectors of the medical community.

- Investigate opportunities to carry out awareness in amongst certain sectors of the medical community such as rapid access lung cancer clinics

Appendix 1: NRCS Knowledge gaps Phase 2

Research Theme 1: Improving the effectiveness of radon preventive measures and radon remedial work

No	Knowledge gap description	Priority
1	A literature review of research into the effectiveness of passive prevention systems should be carried out so that the findings can be used to inform the next revision of Technical Guidance Document C.	High
2	Installation of passive sumps have been shown to reduce radon concentrations in new builds. Field studies to estimate the reductions in radon levels that can be achieved using passive sumps are required.	High
3	The effectiveness of passive prevention systems in schools in Ireland could be assessed using data from newly built schools.	Low
4	Based on the results of the NUIG research investigating the potential reduction in radon levels achieved by passive sumps in new builds, the effectiveness and feasibility of converting standby sumps in existing homes into passive sumps should be considered.	Low
5	Continue to support research on the effect of emerging construction and retro fit technologies on indoor radon levels	Medium
6	What is the optimum fan power that should be used in active radon sump systems and what is the optimum positioning of radon fan exhausts on buildings being remediated?	Medium
7	Radon originates from the ground, however there is the possibility that building materials could also contribute to high radon levels. The contribution made by building materials to indoor radon levels should be established.	High

Research Theme 2: Better targeting of measures and resources

No	Knowledge gap description	Priority
1	Completion and documentation of the EPA validation of the TCD map	High
2	Determine the implications of the new map on radon policy including Building Standards and radon risk assessment	High
3	Establish the new map as a communication tool for policy makers, stakeholders and the public	High
4	A programme and procedure for updating the radon risk map should be developed to ensure the map remains current. This should take account of the implications of changing the radon risk map as set out under Research theme 2.	Medium
5	The radon risk map could be improved by carrying out research in areas with anomalously high radon levels that are associated with karstified limestone.	Medium
6	Carry out behavioural research trials with the ESRI to test different communications and/or financial incentives and assess their impact on radon testing and remediation rates.	High
7	Research to update the NRCS metrics should be carried out as set out in the NRCS Phase 2.	High
8	A programme of reviewing the appropriateness of current NRCS metrics and the frequency at which they are updated should be developed. New metrics should be considered as they arise and included in the programme.	Medium
9	Modelling work to estimate target values for NRCS metrics should be investigated, particularly for the population weighted average which is a key metric required to estimate the number of radon related lung cancers.	Medium

Research Theme 3: Developing radon risk communication and raising awareness

No	Knowledge gap description	Priority
1	An assessment of the baseline level of awareness of radon among solicitors, surveyors, landlords and new home owners is required.	High
2	Once baseline levels of awareness have been established, a programme of awareness targeting these groups should be carried out and awareness levels then re-measured.	High
3	Review and update EPA radon communications to incorporate the findings of the EPA/ESRI research	Medium
4	Investigate opportunities to carry out awareness amongst certain sectors of the medical community such as rapid access lung cancer clinics	Low

Appendix 2: Feedback on the review of the Phase 1 Knowledge gaps paper

Feedback from the NRCS co-ordination group on the review of the Phase 1 Knowledge gaps paper is summarised below:

- The response rate to the initiative to provide free detectors and grant aided remediation was not as high as expected.
- The response rate to the financial incentives survey demonstrated that achieving behavioural change is extremely difficult and is something that could be looked at by behavioural economists.
- Based on the results of research carried out, there should be more support for primary prevention.
- More consideration should be given to passive prevention and this is a subject for research funding.
- The addition of radon questions in the conveyancing process has not had much impact on the rate of home testing and that this may be due to a lack of understanding regarding the questions.

A summary of research topics and issues identified by researchers at the EPA workshop to set radiation research priorities for Ireland are outlined below:

- Funding. There was support for the development of a business case that would outline the current cost of radon related lung cancers to the State. This would set out how the investment of a proportion of this cost could be used to fund the research work required to protect the population from radon exposure. The potential for this work to be co-funded by industry was suggested.
- Development of a radon risk model. Ultimately, the radon risk map would be comprised of a model that would predict individual radon risk by taking account of:
 - Underlying geology including bedrock geology, quaternary geology, subsoil permeability and aquifer type
 - The building including the building materials, the house type and age, new building practices, energy retrofitting of existing homes, membrane installation, passive sump effectiveness and building control during construction
 - The occupants of a home including their occupancy time, ventilation and heating preferences and their smoking habits

This radon risk map would be future proofed by ensuring it is updated as new data become available from surveys such as the TELLUS survey [5], new radon measurement data and from updated bedrock maps.

- Socio-economic differences. There was some discussion as to whether there are socio-economic differences that impact on radon exposure. This and the question of whether there is an urban/rural divide in risk from radon exposure were raised as potential research topics.

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