Action Plan to Identify and Remedy Irish Houses with Radon Concentrations above the National Reference Level

Radiological Protection Institute of Ireland
An Institiúid Éireannach um Chosaínt Raideolaíoch

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Executive Summary

The Institute has been measuring radon in Irish homes since 1989. In the period up to mid-August 2005, measurements have been completed in 27,260 homes. Of these, 3,422 have radon concentrations above the national Reference Level of 200 Bq/m$^3$, with 192 above 1,000 Bq/m$^3$. On the basis of the National Radon Survey, some 91,000 homes are predicted to have radon concentrations above 200 Bq/m$^3$. Thus less than 4% of the homes above the Reference Level have so far been identified.

This Action Plan has been developed with a view to increasing the rate at which homes with high radon concentrations are identified and number which are subsequently remediated.

The Action Plan is structured along the following lines

- Recent epidemiological data on the health risks from exposure to radon is evaluated;
- The current information on radon in Ireland is summarised and the various initiatives that have been undertaken are described; and
- A review of the radon programmes in other countries is presented in which policies and initiatives that have been particularly effective are highlighted.

Based on the information in the preceding sections, a six-point programme is outlined. This includes targeted and high-profile media campaigns, better implementation and enforcement of the Building Regulations, a programme of free radon measurements in High Radon Areas and the introduction of financial incentives to assist householders with radon concentrations in their homes above the Reference Level.

Inherent in the Action Plan is a recognition that exposure to radon in the home needs to be considered in a broader context than heretofore. The Institute clearly has a central role to play, but the issue needs to be addressed on a number of fronts by a number of different Government Departments and agencies working together if an effective programme is to be put in place.
1. Radon and its Health Effects

1.1 Background

Radon is a naturally occurring radioactive gas. It is colourless, odourless and tasteless. Radon is formed in the ground by the radioactive decay of uranium, which is present in small quantities in all rocks and soils. Because it is a gas, radon can move freely through soil enabling it to enter the atmosphere or seep into buildings. Radon which surfaces in the open air is quickly diluted to harmless concentrations, but it can build up to unacceptably high concentrations indoors.

Once radon enters a building it quickly decays to produce radioactive particles, some of which remain suspended in the air. When inhaled, these particles can be deposited in the airways and attach themselves to lung tissue. These then give a radiation dose that may eventually lead to lung cancer.

Many environmental pollutants are classified as cancer-causing solely on the basis of laboratory studies using either animals or cell cultures. In the case of radon, there is direct evidence from human studies of a link between exposure to radon and lung cancer. The International Agency for Research on Cancer, a part of the World Health Organisation, has placed radon in the same group of carcinogens as asbestos and tobacco smoke as a cause of lung cancer.

Long-term exposure to radon can result in a significant radiation dose to the skin, while ingestion of radon dissolved in drinking water can irradiate the lining of the stomach. However, there is no epidemiological evidence linking such exposures with an increased risk of cancer\(^1\).

In many countries exposure to radon gas in the home represents the largest proportion of the radiation dose received by the general public\(^2\).

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1.2 Estimating Risks from Radon Exposure

1.2.1 Historical Data

Exposure to radon is not a new phenomenon and documentary evidence from as far back as the 16th century indicates that elevated radon exposure was probably responsible for excess lung cancer mortality of miners in some Central European mines. In the last 40 years, several epidemiological studies have been conducted on uranium and other miners who were occupationally exposed to radon, primarily in Canada, Czechoslovakia, Sweden and the United States. These have been reviewed in detail elsewhere³. One of the largest of these studies, involving over 2,700 lung cancer deaths in 68,000 miners who between them had accumulated 1.2 million person-years of exposure, was carried out in the United States and published in the 1990s⁴.

In attempting to apply the risk estimates from the miners’ studies to the general population, several differences between the two groups have to be considered. These include differences in age and sex distributions, the longer period of time over which members of the public are likely to be exposed and differences in the physical environment between mines and buildings. While the miners’ data proved conclusively that long term exposure to radon increases the risk of lung cancer, it was recognised that the many differences between miners and the general population could influence the risk factors for both groups. However, in order to get some estimate of the radon problem in homes, the authors of the US miner study concluded that, on the assumption that these data could be applied directly to radon exposure in the home, radon may be responsible for approximately 9% of all lung cancer deaths in the United States.

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Since the miners' studies were undertaken, several case-control studies have been conducted to directly quantify the risk following exposure to radon in the home. A number of these studies were of low statistical power and, as a result, the calculated risk factors had large uncertainties. However, the risk factors derived were still broadly consistent with the miners’ data. In 1999, an extensive study by the US National Research Council estimated that 10-15% of all lung cancers in the United States were caused by radon.

A number of geographical correlation studies have also investigated the relationship between the risk of lung cancer and exposure to radon in the home. These studies compare exposure to radon and the incidence of lung cancer across large groups of the population and assume that the same risk relationship exists at the individual level. With this approach it is almost impossible to properly account for confounding factors that could influence the observed incidence of lung cancer. The most important confounding factor is smoking which can also show significant geographical variation and it is impossible to separate risk due to smoking from that due to radon unless the smoking status of each affected individual is known. For this reason these types of studies are normally not considered to provide useful information on the risks associated with exposure to radon.

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5 A case-control study is based on individual measurement and individual risk i.e. the exposure to radon of each individual in the study group is either measured or estimated.


1.2.2 Most Recent Data

In December 2004, the results of a joint analysis of 13 individual studies of residential radon exposure in nine European countries were published\textsuperscript{13}. The studies had been carried out in Austria, the Czech Republic, Finland (2), France, Germany (2), Italy, Spain, Sweden (3) and the United Kingdom. The size of each of these studies on its own was too small to provide statistically significant results, but together they add up to the largest study of the risks of radon exposure in the home ever undertaken.

The study analysed 7,148 lung cancer cases and 14,208 controls. The principal conclusion reached was that, while the underlying lung cancer risk for active smokers was considerably higher than for lifelong non-smokers, the risk to both groups increased by approximately 16\% for every 100 becquerels per cubic metre (Bq/m\textsuperscript{3})\textsuperscript{14} of radon exposure in the home. In addition, this risk seemed to apply even at relatively low radon exposures, typically below the Reference Levels that apply in a number of countries (see section 4.1). In early 2005, a comparable study undertaken in the United States reported similar results\textsuperscript{15}. The results of both studies provide risk factors for radon exposure in the home that are consistent with those derived from the earlier studies on miners occupationally exposed to radon.

It is known that at high radiation doses a linear relationship exists between radiation exposure and risk of developing cancer. If the radon dose is doubled then the risk of developing cancer is also doubled. For radiation protection purposes, it is assumed that the linear relationship also applies at much lower doses. This is called the Linear-No-Threshold (or LNT) Hypothesis. The most recent European study found that, in the case of radon, the LNT Hypothesis appears to hold down to about 150 Bq/m\textsuperscript{3}. Below this concentration, there is no conclusive evidence either way. However it is important to note that, as in all other fields of radiation protection, if the LNT Hypothesis does not hold and/or there is a threshold below which there is no risk, this could significantly affect the estimated risks.


\textsuperscript{14} The becquerel is the unit of radioactivity, equivalent to one radioactive disintegration per second.

1.3 Links between Radon and Smoking

It is generally accepted that radon is the second most important cause of lung cancer after tobacco smoking. It has previously been shown\textsuperscript{16,17} that the relationship between exposure to radon and tobacco is greater than the sum of the individual risks, but less than multiplicative. These data were derived from studies of miners exposed to radon and until now no study of radon exposure in the home provided definitive information on the risks from radon in combination with smoking.

The recent European study recorded detailed smoking histories for all individuals and that allowed the relationship between smoking and radon to be examined. The study found that, on average, the risks of contracting lung cancer before age 75 at radon concentrations of 0, 100, 200 and 400 Bq/m\textsuperscript{3} for lifelong non-smokers are 0.41%, 0.47%, 0.55% and 0.67% respectively. For active smokers, the corresponding rounded values are 10%, 12%, 13% and 16%. Ex-smokers were also found to be at significant risk from radon for a number of years after they had stopped smoking.

These data can be used to calculate the ‘excess’ risk due to radon alone, defined as the risk at a specified radon concentration less that risk at zero radon concentration. This is approximately 1 in 30 for active smokers and 1 in 700 for lifelong non-smokers at a radon concentration of 200 Bq/m\textsuperscript{3}. Therefore the risk to active smokers from radon is approximately 25 times greater than the risk to lifelong non-smokers. This suggests that the majority of lung cancers due to radon will be observed in people (active smokers but also ex-smokers) whose lungs have been damaged by tobacco smoke.

The application of these statistics to Irish demographic data is discussed in section 2.3.


2. Current Situation in Ireland

2.1 National Reference Level

In 1990 the Government set a national Reference Level of 200 Bq/m³ for radon exposure in the home. Based on an assumed occupancy of 7000 hours per year, this equates to an annual radiation dose of 5 millisievert (mSv)\(^{18}\). In Ireland, the average annual radiation dose is 3.62 mSv, of which 2.25 mSv is due to radon\(^{19}\). This is shown in the pie-chart in Figure 2.1.

![Pie chart showing sources of radiation dose in Ireland]

Total = 3.62 mSv

A Reference Level is not a rigid boundary between safety and danger. It represents a level at which one should consider taking action to reduce the radon level. The Reference Level for homes represents a level of risk for the general population similar to risks such as fatal accidents on the road or deaths from accidental falls. It is estimated that approximately 91,000 homes, representing 7% of the national housing stock, have radon concentrations in excess of the national Reference Level\(^{20}\).

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\(^{18}\) The sievert is the unit of radiation dose. The millisievert is one thousandth part of a sievert.


2.2 Radon Measurements in Houses

2.2.1 UCD National Survey
The first study to determine the extent of the radon problem in Ireland was carried out by the Physics Department of University College Dublin (UCD) between 1985 and 1989\textsuperscript{21}. This survey measured radon in 1,300 randomly-selected homes. Because it was based on population, the number of radon measurements was higher in urban areas, where there are more houses, than in rural areas, which are more sparsely populated. Using the results of the survey, an average radon concentration in Irish houses of 60 Bq/m\textsuperscript{3} was calculated and it was estimated that approximately 4\% of the national housing stock had an annual average radon concentration in excess of 200 Bq/m\textsuperscript{3}.

2.2.2 RPII National Radon Survey
Between 1992 and 1999 the RPII carried out a more comprehensive survey of radon concentrations in Irish homes, the National Radon Survey\textsuperscript{22}. Unlike the earlier UCD survey, the RPII survey measured radon in homes on a geographical basis. The Irish 10 km x 10 km National Grid was used as the basic geographical unit of the survey. The principal objective was to quantify the scale of the radon problem in Ireland and to identify areas where there was a higher risk of finding high indoor radon concentrations.

Radon measurements were completed in 11,319 houses, representing a sampling frequency of 1 in 116 of the national housing stock at the time. All measurements were made for a continuous 12-month period. Radon concentrations in the measured houses ranged from 10 to 1,924 Bq/m\textsuperscript{3} with a population-weighted average indoor radon concentration of 91 Bq/m\textsuperscript{3}. Using published national statistics\textsuperscript{23} it was estimated that approximately 91,000 houses, or 7\% of the total, had radon concentrations above 200 Bq/m\textsuperscript{3} with around 700 of these exceeding 1,000 Bq/m\textsuperscript{3}.


Estimates of the national average indoor radon concentration for a number of other countries are shown in Figure 2.1. This places Ireland at the upper end of the range with an average value that is over four times that of the United Kingdom and approximately twice that of Canada and the United States. National averages conceal the high regional and local variability that exists in radon concentrations (Figure 2.2).24

The concept of High Radon Areas, defined as any national grid square where 10% or more of the houses are predicted to have an annual average radon concentration above the national Reference Level of 200 Bq/m³, was developed. High Radon Areas are present in all counties but there is a significant concentration of such areas in the north-west and south-east of the country, as well as in the Tralee and Castleisland region of county Kerry. National Grid Squares classified as High Radon Areas have been identified in every county.

County maps showing High Radon Areas have been published on the RPII website www.rpii.ie. A map of Ireland showing High Radon Areas is attached as Figure 2.3.

The national grid comprises 837 grid squares, of which 234 (28%) are designated as High Radon Areas. These contain 59,000 of the homes predicted to have radon concentrations above 200 Bq/m³, which is 21% of all houses within High Radon Areas. The remaining 32,000 homes predicted to have radon concentrations above 200 Bq/m³ are located in the remaining 603 grid squares. In High Radon Areas, 1 in 5 houses exceeds the national Reference Level while in other parts of the country the incidence is 1 in 30. Summary statistics for the number of grid squares with predicted percentages of homes above the Reference Level are given in Table 2.1.

The data generated by the National Radon Survey can also be compiled on a county basis as given in Table 2.2. Radon concentrations above the Reference Level were found in all counties and in 13 counties they exceeded 1,000 Bq/m³. The highest average radon concentration and the highest percentage of homes above the Reference Level were both found in county Sligo.

These data refer to the situation as it applied at the end of 1997 and take no account of radon concentrations in new homes built since that date.

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Figure 2.1

Average Radon Concentrations in Selected Countries

Figure 2.2

Maximum Reported Radon Concentrations in Selected Countries
Figure 2.3

Map of Ireland showing High Radon Areas
Table 2.1  
Summary Statistics for the Percentage of Homes Predicted to Exceed the Reference Level

<table>
<thead>
<tr>
<th>Homes Predicted to exceed 200 Bq/m$^3$</th>
<th>Number of Grid Squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-15%</td>
<td>96</td>
</tr>
<tr>
<td>15-20%</td>
<td>40</td>
</tr>
<tr>
<td>20-25%</td>
<td>41</td>
</tr>
<tr>
<td>25-30%</td>
<td>25</td>
</tr>
<tr>
<td>30-35%</td>
<td>10</td>
</tr>
<tr>
<td>35-40%</td>
<td>12</td>
</tr>
<tr>
<td>40-45%</td>
<td>6*</td>
</tr>
<tr>
<td>45-50%</td>
<td>3**</td>
</tr>
<tr>
<td>Over 50%</td>
<td>1***</td>
</tr>
</tbody>
</table>

* located in counties Carlow, Clare, Galway (2), Kilkenny and Mayo.  
** located in counties Galway, Mayo/Sligo and Waterford.  
*** located in county Galway.
Table 2.2
Results of the National Survey of Radon in Houses

<table>
<thead>
<tr>
<th>County</th>
<th>Number of Measured Houses</th>
<th>Number of Houses &gt;200 Bq/m³</th>
<th>Radon Concentration (Bq/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>194</td>
<td>30 (15%)</td>
<td>123</td>
</tr>
<tr>
<td>Carlow</td>
<td>180</td>
<td>5 (3%)</td>
<td>67</td>
</tr>
<tr>
<td>Cavan</td>
<td>742</td>
<td>66 (9%)</td>
<td>88</td>
</tr>
<tr>
<td>Clare</td>
<td>1211</td>
<td>71 (6%)</td>
<td>76</td>
</tr>
<tr>
<td>Cork</td>
<td>487</td>
<td>18 (4%)</td>
<td>69</td>
</tr>
<tr>
<td>Donegal</td>
<td>155</td>
<td>6 (4%)</td>
<td>73</td>
</tr>
<tr>
<td>Dublin</td>
<td>1213</td>
<td>181 (15%)</td>
<td>112</td>
</tr>
<tr>
<td>Galway</td>
<td>932</td>
<td>52 (6%)</td>
<td>70</td>
</tr>
<tr>
<td>Kerry</td>
<td>480</td>
<td>29 (6%)</td>
<td>90</td>
</tr>
<tr>
<td>Kildare</td>
<td>181</td>
<td>16 (9%)</td>
<td>100</td>
</tr>
<tr>
<td>Kilkenny</td>
<td>334</td>
<td>17 (5%)</td>
<td>83</td>
</tr>
<tr>
<td>Laois</td>
<td>145</td>
<td>6 (5%)</td>
<td>60</td>
</tr>
<tr>
<td>Leitrim</td>
<td>524</td>
<td>41 (8%)</td>
<td>77</td>
</tr>
<tr>
<td>Limerick</td>
<td>132</td>
<td>8 (6%)</td>
<td>75</td>
</tr>
<tr>
<td>Longford</td>
<td>124</td>
<td>14 (11%)</td>
<td>112</td>
</tr>
<tr>
<td>Louth</td>
<td>1184</td>
<td>152 (13%)</td>
<td>100</td>
</tr>
<tr>
<td>Mayo</td>
<td>233</td>
<td>18 (8%)</td>
<td>102</td>
</tr>
<tr>
<td>Meath</td>
<td>120</td>
<td>4 (3%)</td>
<td>68</td>
</tr>
<tr>
<td>Monaghan</td>
<td>286</td>
<td>7 (2%)</td>
<td>68</td>
</tr>
<tr>
<td>Offaly</td>
<td>235</td>
<td>17 (7%)</td>
<td>91</td>
</tr>
<tr>
<td>Roscommon</td>
<td>270</td>
<td>54 (20%)</td>
<td>145</td>
</tr>
<tr>
<td>Sligo</td>
<td>852</td>
<td>63 (7%)</td>
<td>79</td>
</tr>
<tr>
<td>Tipperary</td>
<td>162</td>
<td>20 (12%)</td>
<td>119</td>
</tr>
<tr>
<td>Waterford</td>
<td>289</td>
<td>20 (7%)</td>
<td>91</td>
</tr>
<tr>
<td>Westmeath</td>
<td>469</td>
<td>54 (12%)</td>
<td>99</td>
</tr>
<tr>
<td>Wexford</td>
<td>185</td>
<td>24 (13%)</td>
<td>131</td>
</tr>
<tr>
<td>Wicklow</td>
<td>12</td>
<td>3 (15%)</td>
<td>1562</td>
</tr>
</tbody>
</table>
2.2.3 Regional Surveys (1989-1992)

In the period 1989-1992 the RPII carried out a number of regional radon surveys in counties Clare, Galway, Mayo and north Kerry\textsuperscript{25}. These surveys pre-dated the RPII National Radon Survey and their purpose was to collect further information in the areas identified in the UCD National Survey as having the highest radon concentrations in homes. A survey involving radon measurements in 680 houses in the southern part of Cork city was also completed.

Radon measurements were completed in 1,755 houses of which 159 had radon concentrations above the national Reference level of 200 Bq/m\textsuperscript{3}. Unlike the National Radon Survey, only one detector was installed in each house, normally in the ground floor living area. All measurements were made for a period of three months and were seasonally adjusted using seasonal correction factors derived for the UK housing stock\textsuperscript{26}. This gives the best possible estimate of the average radon concentrations to which the house occupants are exposed.

Significant regional variation was observed, from an average radon concentration of 31 Bq/m\textsuperscript{3} in north Kerry to 160 Bq/m\textsuperscript{3} in the Salthill area of Galway city. The highest individual result was 2,399 Bq/m\textsuperscript{3}, also in Salthill.

2.2.4 Castleisland Survey

In July 2003, a radon measurement carried out in a house in Castleisland showed an annual average radon concentration of 49,000 Bq/m\textsuperscript{3}. This is almost 250 times higher than the national Reference Level of 200 Bq/m\textsuperscript{3}. Both of the adult occupants of the house have died from lung cancer – one was a former smoker, having ceased at 20 years of age, while the other occupant had never smoked\textsuperscript{27}.

Following this discovery, the RPII wrote to all of the approximately 2,500 householders living in the four national grid squares adjacent to the town of Castleisland. The letter made them aware of the very high concentration that had been identified and urged them to have their homes tested for radon. The survey measured radon in 383 homes.


and identified 52 homes, or 14% of those sampled, with radon concentrations above the national Reference Level for homes of 200 Bq/m$^3$. Of these, six had concentrations above 1000 Bq/m$^3$, and the highest was 6184 Bq/m$^3$. This is the fourth highest radon concentration ever found in a house in Ireland.

2.2.5 Other Radon Measurements

In addition to the measurements of radon concentrations carried out as scientific studies, since 1992 the RPII has offered a commercial radon measurement service to all householders. Because the majority of these measurements were made for a period of less than one year, the results were seasonally adjusted as mentioned in section 2.2.3.

A detailed summary of all radon measurements (including those from the National Radon Survey) completed by the RPII up to 12$^{th}$ August 2005 is given in Appendix 1. Where more than one set of radon measurements were made in a house, only the most recent has been included. All post-remediation measurements were excluded from the analysis.

These data are not random and cannot be compared directly with the results of the National Radon Survey. However, the data do demonstrate a number of important features

- Radon concentrations over 1,000 Bq/m$^3$ have been identified in 17 counties, the exceptions being Cavan, Donegal, Laois, Longford, Louth, Meath, Monaghan, Offaly and Westmeath;

- Radon concentrations above 2,000 Bq/m$^3$ have been found in counties Clare, Cork, Galway, Kerry, Mayo, Sligo, Tipperary, Waterford, Wexford and Wicklow. Sixteen of the 42 houses in this category are located in county Kerry;

- The highest individual radon concentrations are found in previously identified High Radon Areas; and

- 3,422 (3.8%) of the predicted 91,000 houses with radon concentrations over the Reference Level have been identified.
2.3 Risks from Radon in Ireland

Ireland has an average radon concentration of 91 Bq/m$^3$ compared with a European average of 59 Bq/m$^3$. To derive the risks from radon in Ireland, this value needs to be applied to the risk estimates discussed in section 1.3 in combination with the national smoking habits of the 1990s (which are relevant to the current incidence of lung cancer). Statistical analysis leads to the conclusion that radon alone causes approximately 13% of all lung cancer deaths every year in Ireland. This corresponds to 195 lung cancer deaths, of which 91.5% (178) would be observed in active and ex-smokers and 8.5% (17) in lifelong non-smokers.

These are best estimate values and in any calculation of this nature there is some inherent uncertainty. This needs to be borne in mind when the numbers are being quoted. The RPII has previously estimated 10-15% of the approximately 1,500 lung cancer deaths in Ireland each year can be linked to radon. This equates to 150 to 200 lung cancer deaths annually. The RPII figure was initially based on the international risk estimates from the miners’ studies. More recently, the RPII, together with the National Cancer Registry of Ireland, has reviewed the results of the recent European study of radon exposure in the home.\(^{28}\) When applied to the Irish situation, the results of the research confirm that radon is directly responsible for up to 200 lung cancer deaths each year.

There is wide variability in the radiation dose received by individuals within the Irish population. This is influenced not only by the radon concentration present but also by the amount of time spent indoors. The longer a person remains indoors, the higher their exposure to radon. To date, the RPII has completed radon measurements in approximately 27,000 Irish homes of which around 3,400 have radon concentrations above 200 Bq/m$^3$ and 200 exceed 1,000 Bq/m$^3$. The highest concentration recorded to date is 49,000 Bq/m$^3$. Thus the residents of many Irish homes are at a much higher risk from radon than indicated by calculations made for exposure at either the average radon concentration in Irish homes or at the national Reference Level.

Lung cancer has a latency period of about 10 to 15 years. Therefore the incidence of lung cancer at any given time is principally dependent on the smoking habits of the population up to 15 years previously. The current trend in Ireland is of an overall

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reduction in smoking\textsuperscript{29}. In 1970 some 46\% of adults smoked. This dropped to approximately 30\% in 1990 and to 27\% in 2003.

At the individual level, the risks will be influenced by the number of cigarettes smoked per day, the number of years since smoking ceased and the extent of exposure to passive smoking. Because of the increased risk from radon to smokers, as the prevalence of cigarette smoking falls, the number of lung cancer deaths due to radon in smokers will also fall, as will the number of lung cancer deaths generally. The much smaller number of radon induced lung cancers in non-smokers will remain the same over the next few years, but will increase marginally as the number of never smokers increases.

While there are significant differences in the risks from radon between lifelong non-smokers, ex-smokers and active smokers, the overall risk is still significant. For example, accidents on the road account for approximately 300 fatalities annually, while cancer of the cervix kills around 70 women every year in Ireland. In 2003 there were 67 deaths following accidents in the workplace and 17 deaths caused by meningitis.

2.4 Initiatives to Promote Radon Awareness

2.4.1 Introduction

In July 2000, the State received high-level legal advice to the effect that it should err on the side of making a maximum effort to inform the public on the advisability of testing premises for radon and remediying buildings with high radon concentrations. The legal advice went on to underline the importance of focusing attention on High Radon Areas, noting that while a reasonable level of publicity should be carried out everywhere, there was a need to carry out publicity more intensely in relation to areas with high radon concentrations. It was also recommended that High Radon Areas should be fixed in the public awareness together with clear ideas of how to ameliorate the risk.


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Finally, the legal advice highlighted the fact that any scientific development on the link between radon and health might require a review of the legal advice on information dissemination.

2.4.2 Available Information

For several years the RPII has published general information on radon on its website www.rpii.ie. Every year the RPII issues typically six to eight press releases on radon and takes part in up to 100 national and local media interviews on both television and radio. A freephone number exists through which members of the public can obtain additional information.

Several reports detailing the RPII’s work on radon have been published and scientific papers are presented at national and international meetings. RPII also staff make regular presentations to professional and other interested groups and articles on radon are written for trade and other relevant magazines.

More specific initiatives by the RPII and others to improve the knowledge of the general public in relation to radon are discussed below.

2.4.3 Radon Road Shows

In October 2004 the RPII commenced a series of radon road shows in High Radon Areas. The purpose of each road show is to deliver the message of the risks from radon to a local audience through a number of planned and co-ordinated initiatives. This involves a combination of meetings with the local Chamber of Commerce, a presentation at a school where high radon concentrations were previously found and the manning of a radon information stand in a local shopping centre. Each visit is preceded by a Press Release and a briefing of local and national media and every effort is made to maximise television and radio coverage.

To date, road shows have taken place in Ballina, Sligo and Kilkenny. Further visits to Waterford and Tralee are planned before the end of 2005.

2.4.4 National Radon Forum

Since 2002, the Institute has organised a National Radon Forum to highlight the radon issue and to provide the opportunity for legislators, radon measurement laboratories, local authorities, the building and remediation industries and the research community
to interact. These Forums have been highly successful as they have provided the opportunity for the different sectors, all of whom are essential components of any national programme aimed at reducing the risk from radon, to meet and debate the issues of topical interest in relation to radon.

2.4.5 Involvement of Local Authorities

In December 2004 the Institute wrote to all County Managers urging that the health risk associated with exposure to radon be brought to the attention of the Chairman of the Environmental Strategic Policy Committee with a view to having radon included in the Authority’s Environmental Corporate Plan. One county replied saying that they already had a radon programme in place.

In June 2005 the Institute again wrote to all County Managers asking them to provide information on the actions taken in response to the Institute’s previous letter. Based on the responses received, nine local authorities have a programme in place to provide information on radon and/or to measure radon in the properties for which they are responsible. The responses received to date are summarised in Appendix 2.

2.4.6 TNS mrbi Survey

In late 2004 the RPII commissioned research by TNS mrbi on a number of issues related to radiation protection. A number of questions dealt with knowledge of and attitudes to radon.

There was widespread awareness of radon gas – three quarters of those interviewed claimed to have heard of the gas, with awareness greatest amongst males. This high level of awareness was supported when respondents were asked to reveal their source of awareness – fewer than 1 in 12 were unable to provide an information source. Television (34%) and newspapers/magazines (29%) were the two most commonly nominated sources with others mentioned at significantly lower levels. Approximately 1 in 7 named school/college and the radio as a source of awareness.

Concern regarding radon gas in the home showed a pattern similar to that observed for radiation in general, with the population fairly evenly split between those with a concern (47%) and those without (51%).
2.5 Radon Prevention

2.5.1 Introduction
As the results of the National Radon Survey became available it became clear that there were a number of areas in the country where radon concentrations above the Reference Level were present in a significant number of houses. Using the experience of other countries, the Department of the Environment, Heritage and Local Government (DEHLG) took steps to reduce radon ingress into new homes through amendments to the building regulations.

2.5.2 Amending Building Regulations, 1997
The 1997 amending Building Regulations require that reasonable precautions are taken to avoid danger to health and safety caused by substances in the ground. Radon gas is such a substance and the DEHLG has published guidance through Technical Guidance Document-C which requires that all new homes, built since 1st July 1998, should have a potential means to extract radon from the substructure such as a standby radon sump. In addition, all new houses in High Radon Areas require the fitting of an approved sealed membrane (radon barrier) of low radon permeability over the footprint of the building.

2.5.3 Effectiveness of the Amending Building Regulations
To test the effectiveness of the amending Building Regulations, the Institute has carried out three surveys in Ennis, Tralee and Kilkenny. These were undertaken in 2001, 2002 and 2003 respectively. The three towns are located in High Radon Areas and therefore all houses built since 1st July 1998 should have had both radon barriers and stand-by radon sumps installed at the time of construction.

In the Ennis survey, radon concentrations were measured in homes built after 1st July 1998 and compared with the results of the National Radon Survey for the same grid square. In the Tralee and Kilkenny surveys, radon measurements were also made in a selection of houses built between 1992 and 1997. This protocol was introduced because of concerns that building practices could potentially influence indoor radon concentrations\(^{30}\) and that direct comparison with data from the National Radon Survey might provide an incomplete picture. By confining the two subsequent surveys to
houses built since 1992, during which time construction practices would have been similar, this confounding factor was eliminated.

With the exception of one house in county Kilkenny, in all three surveys the average radon concentration, the highest radon concentration and the percentage of houses that exceed the Reference Level are lower in homes built after 1\textsuperscript{st} July 1998. However, in each survey a number of houses built after 1\textsuperscript{st} July 1998 had radon concentrations above the Reference Level.

It is important to realise that the surveys did not involve inspection to determine the presence or absence of a radon barrier. Therefore compliance with the amending Building Regulations could not be confirmed. Failure to implement the amending Building Regulations and/or poor workmanship have to be considered when interpreting the results.

These results confirm that the amending Building Regulations are having a positive effect in reducing radon concentrations in newly-built homes. However, radon testing is still required once the house is occupied so that, if necessary, the stand-by radon sump can be activated by the addition of a fan.

2.5.4 Amendment to Technical Guidance Document C

The results of the Ennis survey and the recommendations that were subsequently made by the RPII resulted in the Department of the Environment, Heritage and Local Government (DEHLG) amending the Technical Guidance Document C (TGD-C) providing guidance on radon protection for new dwellings. The amended form of the TGD-C came into effect from 1\textsuperscript{st} April 2005. DEHLG is also planning to issue a leaflet explaining the protective measures that have been fitted in their house in accordance with the amending Building Regulations, 1997 to all householders and tenants occupying newly built homes.

2.6 Remediation of Homes with High Radon Concentrations

In 2005 the RPII supported a study on the extent of radon remediation in Ireland. Letters were sent to all householders (approximately 3,200 in total) who had radon concentrations above the Reference Level and who had been advised by the RPII to consider remediation. A sub-sample of the replies was statistically selected for analysis. Just under 10% had applied some form of remediation. One third of these had installed radon sumps and approximately 10% had increased indoor ventilation. On this basis one can deduce that approximately 100 homes have had radon sumps installed and this observation is consistent with the experience of the radon remediation industry operating in Ireland.

A study undertaken by scientists at NUI Galway found that cost and the lack of information were the two major disincentives to carrying out remediation. The study was based on questionnaires distributed to 141 Irish householders with radon concentrations in their homes above the Reference Level.

2.7 Available Services

2.7.1 Measurement Services

There are three well-established radon measurement laboratories offering commercial radon measurement services in Ireland. These are the RPII, Radon Ireland and Radon Laboratory Services.

The RPII radon measurement laboratory is accredited to ISO 17025 and undertakes its own internal calibration and quality assurance programme. Radon Ireland and Radon Laboratory Services act as agents for approved radon measurement services based in Sweden and Italy respectively.

Protocols for the measurement of radon in houses have been drawn up by the RPII and these have been adopted by the other two measurement services.

2.7.2 Radon Remediation and Prevention Services

Approximately 10 Irish-based companies offer radon remediation and prevention services. The available services include the retrospective fitting of radon sumps and

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other mitigation in existing houses with identified high radon concentrations as well as
the supply of radon barriers and stand-by sumps for installation in new homes at the
time of construction.

Some of the companies have come together to develop and apply procedures in
relation to issues such as customer service, materials standards, work procedures,
complaints etc. However, there are no external standards applied across the industry.
A list of companies operating in this area is available on the RPII website (www.rpii.ie).
The RPII does not endorse, warrant or otherwise recommend the services provided
by, or available from, any of the listed companies.

2.7.3 FÁS Training Scheme
FÁS is the state training and employment authority established in January 1988 under
the Labour Services Act, 1987 to provide a wide range of services to the labour market
in Ireland. In 2001 FÁS held its first training course on radon gas remediation and
prevention targeted at radon remediation contractors, designers such as architects
and engineers and Local Authority and private sector supervisory staff involved in the
installation and maintenance of radon remediation equipment.

The most recent course was held in Dublin in February 2004.

Further information on the course is available at www.fas.ie/environmental_
training_unit/radon_gas_remediation.html

2.7.4 Sources of Information
The following information brochures have been published:

- “Radon. Radiation in Homes” is published by the RPII and is available online at
  www.rpii.ie

- “Understanding radon remediation. A Householder’s Guide” is published by the
  RPII and is available online at www.rpii.ie

- “Radon in Existing Buildings – Corrective Options” is published by the Government
  Publications Sales Office (Sun Alliance House, Molesworth Street, D2, €5) and is
  also available online from the DEHLG website at www.environ.ie
General information on radon is available on the RPII website. Information on building regulations, technical guidance documents and radon remediation is available on the ‘Building standards’ section of the DEHLG website [www.environ.ie](http://www.environ.ie)

The RPII has issued a poster to all doctor’s surgeries outlining the risk to health from long term exposure to radon and urging householders to have a radon measurement made.
3. Radon Strategies in Other Countries

3.1 Reference Levels

International organisations such as the International Commission on Radiological Protection and the International Atomic Energy Agency have considered the range of Reference Levels that should apply to radon exposure in the home\textsuperscript{33,34}. In formulating this advice, the principal factors taken into account are the absolute risks from radon exposure and the net benefit gained if action is taken to reduce higher concentrations. On this basis, it is recommended that national authorities set a Reference Level in the range 200-600 Bq/m\textsuperscript{3}. Additional advice is that intervention to reduce exposure to radon should always be optimised i.e. it is not sufficient to reduce radon concentrations to marginally below the Reference Level when the use of cost-effective techniques can ensure that much lower radon concentrations can be achieved\textsuperscript{35}.

The majority of European countries have set Reference Levels for radon in houses\textsuperscript{36}. Generally these are in the range of 200 to 400 Bq/m\textsuperscript{3}. In the United States a value of 150 Bq/m\textsuperscript{3} has been set, while in Canada the value adopted on the basis of cost-benefit analysis is 800 Bq/m\textsuperscript{3}. Australia has set a Reference Level of 200 Bq/m\textsuperscript{3}.

In Ireland, the Reference Level for homes is not legally enforceable. However, some countries apply both an advisory Reference Level and an additional, higher, Reference Level which, if exceeded, requires action on the part of the householder. For example, in Sweden, the Reference Level is 200 Bq/m\textsuperscript{3} but radon concentrations above 400 Bq/m\textsuperscript{3} must by law be reduced to below 200 Bq/m\textsuperscript{3}. Switzerland has a similar policy for radon concentrations above 1000 Bq/m\textsuperscript{3}, which must be reduced to below the Reference Level of 400 Bq/m\textsuperscript{3}.

3.2 World Health Organisation International Radon Project

In January 2005 the World Health Organisation (WHO) initiated its International Radon Project (IRP). The principal IRP objectives include the following:


• Identify effective strategies for reducing the health impact of radon;
• Promote sound policy options, prevention and mitigation programmes;
• Raise public and political awareness about the consequences of exposure to radon;
• Raise the awareness of financial institutions supplying home mortgages to the potential impact of elevated radon levels on property values;
• Monitor and periodically review mitigation measures to ensure their effectiveness;
• Estimate the global health impact of exposure to residential radon and so allow resources to be allocated effectively to mitigate the health impact of radon; and
• Create a global database (including maps) of residential radon exposure.

An important overall target of the project is to increase the public and political awareness concerning radon risks and opportunities for prevention and mitigation in participating countries. It is anticipated that the output from the IRP will contribute to more effective and coherent policies and communication activities worldwide. Through the IRP, the WHO and its member states should succeed in putting radon on the environmental health agenda in countries where this has not been the case so far, and in strengthening local and national radon-related activities in countries with on-going radon programmes.

3.3 Public Awareness

In situations where Reference Levels are advisory in nature, it becomes the choice of individual householders to measure for radon and whether or not to take action on the basis of the concentrations present. In such circumstances, the availability of factual information to facilitate informed decision-making becomes central to the national radon programme.

All countries that have set a national Reference Level for radon in houses also provide some degree of associated information. This information covers issues such as radon entry routes into buildings, health risks (including the relationship with smoking),

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measurement protocols and remediation options. This is targeted not only at householders but also at builders and professionals such as architects and engineers. Training courses for remediation professionals are also organised and in Spain, Sweden and the UK a video on radon, which includes information on remediation techniques, is available.

In the United States, the Environment Protection Agency (USEPA) operates a decentralised system for informing the public. This consists of multiple, highly respected organisations that deliver radon messages through established channels to targeted audiences, thereby fostering co-operative partnerships. This involves working with leading organisations that have special expertise, credibility and communications channels to reach target audiences such as doctors, county health officials, public service directors and builders.

Examples of communication channels include the Journal of American Medicine, the American College of Preventive Medicine, American Medical TV and statements by the US Surgeon General. Each target audience becomes a source of information for new target audiences. Thus doctors pass on the message to their patients, local public representatives inform their constituents etc.

Initially the USEPA’s approach focused on the provision of general public information on radon, but more recently, they have opted for more direct strategies. These include continuously providing information to specifically targeted interest groups, prioritising reduction of the highest radon concentrations (which represent the greatest individual risk), promoting radon-resistant new construction, supporting testing and mitigation in connection with real estate transactions and providing information to the public to allow them make knowledgeable decisions with regard to radon. Information on competent measurement and mitigation firms (updated lists of firms, trained and qualified contractors to test or fix houses etc.) is also readily available. The objective is that the householder receives a consistent message on radon from a number of key sources through multiple channels that will repeat and reinforce the need for individual action.

### 3.4 Building Regulations

The implementation of building codes that reduce the ingress of radon into newly constructed houses is a key policy in many countries. Sometimes these codes apply
to all new housing but more often they are focused on High Radon Areas where a significant percentage of new houses would otherwise have radon concentrations above the national Reference Level. Experience in the United Kingdom has shown that the use of radon barriers in the form of a membrane laid across the ground floor of the house will not always ensure that radon concentrations in the house will be below the Reference Level. This is similar to the experience in Ireland. This is because of difficulties in ensuring that the barrier is not damaged during installation and that all gaps around pipe work are properly sealed.

In Sweden, following the introduction of revised building codes in 1988, a geotechnical investigation has to be made for all building sites. This includes measuring radon in soil gas. Depending on the radon concentration found, the ground is declared “high”, “normal” or “low” radon. According to this classification, the foundations of the new building will be different (radon-safe, radon-protective or traditional).

A European review has been carried out on national policies on the use of protective measures to protect new houses from radon. This shows that, in respect of building regulations, Ireland is well ahead of many other countries. Apart from Ireland, national legislation that requires construction practices to protect newly built houses from radon is in place in the Czech Republic, Finland, Switzerland and the United Kingdom. In Germany, regulations apply only in the former uranium mining province of Saxony. In Sweden recommendations and advice have been issued and control of new buildings is exercised through having a legally enforceable Reference Level. Belgium and Spain are both presently developing appropriate regulations. In the Netherlands, only very low radon levels have been found in houses and regulation through building codes is not considered necessary. A similar situation applies in Denmark.

3.5 Remediation Grants
An extensive radon grants scheme has operated in Sweden for many years. The scheme applies to single family homes with radon concentrations above 200 Bq/m³. The grant covers half the cost of remediation up to a maximum of SKK15,000 (approximately €1,600). The grants scheme is operated by the Ministry of Housing,


Building and Planning and administered by the local authorities. There were 981 successful grant applications in 2003 and this increased to 1,303 in 2004.

Finland offers financial support for radon remediation through a more general grants scheme for health-related remedial work in private homes. The scheme is administered by local authorities on behalf of the Housing Fund of Finland. The maximum grant payable is 40% provided the total remediation costs exceed €7,000.

In the UK, grants for radon remediation are included as part of the housing repair grant scheme. These are managed by the local authorities on a discretionary basis and are means-tested. Normally radon grants are issued only as part of funding for other works that are necessary to make the property habitable. However, free radon measurements are offered to all householders in Radon Prone Areas (in the UK, this is any area where more than 1% of homes are predicted to exceed the national Reference Level).

In the Czech Republic a radon grants scheme has been in operation for the past 15 years. A grant of up to CZK150,000 (approximately €4,000) is available to owners of private houses with radon concentrations above 1,000 Bq/m$^3$. A reduction in radon concentration to below the national Reference Level must be confirmed before the grant is paid.

Limited radon grants are also available in Austria, Belgium and Luxembourg.

3.6 Radon and House Purchase

A number of European countries encourage radon measurement at the time of sale and purchase of houses. The radon policies of 20 countries, who together have formed a network to document and harmonise national approaches to dealing with radon, have recently been reviewed$^{39}$. The Czech Republic, Germany, Sweden, Switzerland and the UK have all issued advice to house purchasers on the steps they should take in relation to radon.

In Sweden, the vendor is required by law to make available the results of any radon measurements that have been made. If there is no measurement or if it is an old

measurement result, the purchaser can ask for a clause to be inserted into the contract requiring the vendor to meet the costs of any remediation that may be necessary.

In the UK, a study\textsuperscript{40} on attitudes to radon remediation in south east England recommended that there should be urgent investigation of the ways in which the property market might alleviate the radon problem by making estate agents, solicitors and mortgage providers aware of a need for a property to be certified ‘radon free’ at the point of sale.

To address this issue, a series of questions on radon is now included as part of the local authority search carried out prior to purchase. If the property is identified as being located in a Radon Prone Area, the vendor is asked about any radon measurements that have been made, the concentrations present and, if appropriate, details of any remediation that has been carried out. Where no measurements have been made and the purchaser is concerned that high radon concentrations may be present the advice is that he/she should enter into a “Radon Retention” with the vendor. This is simply a clause in the purchase contract which requires a small percentage of the purchase price to be retained for a fixed period of time and drawn from to pay for remediation should this prove necessary once the house is tested for radon.

In the United States, radon measurement at the time of house sale and purchase is strongly recommended as part of a national strategy\textsuperscript{41,42}. Mortgage lenders have been identified as playing a key role in persuading mortgage applicants to carry out radon testing and some US banks have a policy of routinely testing their residential properties for radon.


A study in Canada showed the most cost-effective strategy to reduce radon exposure was to measure and, where necessary, remediate at the time of house purchase. The same study showed that the cost-effectiveness varied between cities and was greatest where the highest radon concentrations were found.

### 3.7 Role of Local Authorities

Both Sweden and the UK are at the forefront of delivering radon information through local authorities. This philosophy has been developed because of evidence that individuals are more likely to source information locally and to place greater trust in those who deliver it when they live in the same community.

In 1992 the UK launched its “Health of the Nation” strategy. This is a wide ranging strategy co-ordinated by the Department of Health with the aim of improving the health of the population. The strategy focuses on five key areas and 27 targets have been set within these areas to monitor progress. One of the key concepts is that improved health is achieved by means of a contract between central Government, local organisations and individuals with emphasis being placed on the provision of information to facilitate informed choices. Since 1997, radon has been included in the strategy and an evaluation of areas where progress is encouraging, areas where progress is limited, and other areas of concern is reported on an annual basis.

In Sweden, the local municipalities have played an active role in the national radon programme for many years. Since 1980, many municipalities have made radon in soil measurements at new building sites before starting construction. As mentioned above, this has been mandatory since 1988. In addition, some municipalities have decided to undertake surveys of radon in existing houses and to develop localised risk maps. This work is carried out predominantly in areas with known high radon concentrations and the costs are borne by the municipality.

In Finland, central Government has devolved responsibility for the dissemination of general information and advice on radon, particularly in relation to remediation, to the local authorities.

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4. Action Plan for Radon in Irish Homes

4.1 Introduction

The key decision to be made is the degree of prescription that should be applied to a programme aimed at identifying and remedying Irish homes with radon concentrations above the national Reference Level. At one extreme, one could introduce legally-binding Reference Levels and require compulsory radon measurement and remediation of all houses with radon concentrations above the Reference Level at the time of purchase. As part of this approach, the current programme of radon prevention for new homes would need to be continued. However, this type of proscriptive approach itself introduces a number of additional complications that would need to be resolved.

At the other extreme, one can provide general information on radon and leave the choice to individuals on whether or not they wish to measure radon in their home and, if high concentrations are identified, whether or not they wish to remediate.

Many of the countries with an advanced radon programme operate between these two extremes. While general information is readily available, a strategy of targeting specific audiences who can influence public attitudes is often adopted. Such key audiences would include the medical community, public representatives, estate agents, relevant sectors of the building industry, etc.

The high-level legal advice previously referred to has clearly indicated the need for a well publicised, constant approach to the provision of information on radon. The TNS mrbi Survey commissioned by the RPII shows a high awareness of radon, but a much lower understanding of the issues. There are also indications of a significant gap in information on remediation options for householders with identified high radon concentrations. For these reasons the increased provision of targeted information is recommended as the cornerstone of a national programme to reduce the risks from radon. From this starting point a series of specific initiatives can be considered.
4.2 Components of the Action Plan

4.2.1 Access to Information

Radon is both an environmental and a public health issue. To date, radon has been brought to public attention primarily by the RPII and its parent Government Department, (currently) the Department of the Environment, Heritage and Local Government (DEHLG). It would be highly desirable that other relevant Government departments and agencies become actively involved in addressing radon from the public health perspective.

At present, an Interdepartmental Radon Committee comprising representatives of RPII, DEHLG and the Department of Health and Children (DHC) meets on a regular basis to exchange information and discuss policies on radon. This or some other group could co-ordinate, direct and manage an information programme on all aspects of radon. The programme should include a high profile media advertising campaign. The principal areas to be covered by any media and publicity campaign would include general information on radon, radon as a health issue and remediation options.

The approach taken in the United States is to target key audiences and to deliver messages through already established channels. This has worked effectively as individuals tend to be more responsive when the message is received from a respected source. While some targeting of key groups has already taken place, the message needs to be regularly reinforced. For example, statements from the Chief Medical Officer of the DHC or the National Cancer Registry of Ireland would carry significant weight among the medical community while involvement of professional organisations such as the Institute of Engineers or the Institute of Architects would be an effective means of providing information to professionals in the building industry. In addition, broadening the remit of local authorities to allow them play a pivotal role in the remediation of existing houses with identified high radon concentrations has worked well in other countries. To ensure that the various messages about radon are constantly reinforced, the RPII recommends that a network and cascade approach that includes all key stakeholders be adopted.

4.2.2 Building Regulations and Practices

It is acknowledged that Ireland is at the forefront of reducing radon concentrations in new homes through the control of building practices. The 1997 amending Building
Regulations have been shown to be effective in reducing radon concentrations. However, recent studies have shown that a proportion of new homes still have radon concentrations above the Reference Level and it would be desirable to investigate the extent to which the effectiveness of the building regulations in reducing radon concentrations can be improved.

As a first step, the RPII recommends that steps be taken to ascertain the extent to which the building regulations, as they apply to radon, are being implemented. A subsequent programme to improve their effectiveness is likely to involve a range of measures including better supervision and training of tradesmen responsible for laying radon barriers and an improved awareness across all sectors of the building industry of the risks from radon and how these can be reduced.

The Homebond scheme was first introduced in January 1978 to offer purchasers of new houses protection against major structural defects for a certain number of years where they cannot get satisfaction from the original builder. The scheme has since been expanded over the years to cover major non-structural defects. Presently the installation of radon barriers and radon sumps are not covered by Homebond but the scheme could be expanded to include both these practices. This would serve to further underline the importance of radon as a potential health risk and the need to build new homes in a manner that minimises radon ingress from the soil.

4.2.3 Radon Measurement at the Time of House Purchase
In December 2004, the RPII made a submission to the Law Reform Commission (LRC) that radon measurement be included in the conveyancing process. The LRC did not formally address the Institute’s submission as it was considering only changes to components of the existing legislation and therefore a new initiative on radon fell outside the scope of the LRC review.

A less proscriptive approach would be to introduce a “mandatory disclosure voluntary action” scheme similar to that which already applies in certain situations in the UK and in Sweden. Under such a scheme, radon would be considered along with other risks at the time of house purchase. This would raise the awareness of radon as a potential issue but need not hold up the sale of the property. The information to be requested could include

- Is the house located in a High Radon Area?
• Have radon measurements been made?
• If so, do the measured concentrations exceed the Reference Level?
• If so, has remediation been carried out?
• If so, what are the present radon concentrations in the house?

Depending on the answers to these questions and the documentation that is made available by the vendor, both parties will need to agree on whether or not radon is of concern and how they wish to deal with it.

A number of other countries have identified the conveyancing process as an important opportunity for radon measurement and in Canada measurement and remediation at the time of house purchase is a proven cost-effective strategy to reduce radon exposure. The RPII therefore recommends that the Government further investigate the feasibility and justification of the various options for including radon measurement and remediation in the conveyancing process. The role to be played by mortgage providers and lending agencies also needs to be considered.

4.2.4 Free Radon Measurements

The limited available data suggest that there is a greater take-up of measurements when these are offered free-of-charge than when they are offered on a fee-paying basis. For example, take-up rates by county for free radon measurements offered to householders as part of the national radon survey varied between 17 and 36%. In the case of the 2003 Castleisland survey, despite a high profile media campaign the take-up rate for fee-paying measurements was about 17%. A programme of free radon measurements operates successfully in Radon Prone Areas in the UK. In order to encourage householders to undertake measurement, the RPII recommends that consideration be given to offering free measurements to all householders in High Radon Areas.

Approximately 60,000 of the estimated 91,000 homes with radon concentrations above the Reference Level are located in High Radon Areas. The total number of homes in High Radon Areas is approximately 300,000. Because indoor radon concentrations follow a log-normal distribution, most of the houses with the highest radon concentrations will also be located in High Radon Areas.
A programme to measure radon in all these houses would, at current rates (€50.00 per house), cost approximately €15M. In practice, however, the measurement uptake rate is more likely to be around 30%. In addition, the overall cost could be further reduced by placing large measurement contracts at reduced rates. Such an initiative would allow a significant number of homes, as well as a large number of those with the highest radon concentrations, to be identified. If run on a phased basis over, for example, a five-year period the annual costs would be of the order of seven to eight hundred thousand euro.

It would be important that criteria be laid down covering radon measurement protocols and laboratory quality control procedures and that a national database of all results be developed and maintained.

4.2.5 Remediation of Houses with High Radon Concentrations

Measurement is only the first step in reducing the risks from radon. Unless houses with radon concentrations above the Reference Level are remediated, there is no net benefit to the health of the occupants or to the population as a whole as their radiation dose has not been reduced.

Based on studies undertaken in Ireland and elsewhere, it would appear that the cost of remediation is a significant deterrent for householders with high radon levels. For this reason, in the mid-1990s the RPII called for the introduction of a grants scheme to assist householders in carrying out remediation work in their homes. In 2000, the necessary structures were put in place for the implementation of such a scheme, but Government decided not to proceed.

The Institute recommends that consideration be given to providing some form of financial support to assist householders with identified high radon concentrations. The types of support to be considered could include a grant or tax benefit. Using the numbers outlined in section 4.2.4, one could anticipate a maximum of 4,000 homes per year with radon concentrations above the Reference Level being identified. If these were to receive financial assistance of, say, €1,000.00 each, the cost to the Exchequer would be of the order of €4.0M annually.

In practice, the net cost will be significantly less as not all householders will decide to remediate and, of those who do, many will require only a moderate reduction in concentrations and this can be achieved at very moderate cost.
In introducing financial incentives to reduce high radon concentrations, it is important that the quality of the work is guaranteed and that unnecessarily expensive work is not sanctioned. Thus post-remediation measurements should always be undertaken and it may be appropriate to structure the grants scheme in such a way as to ensure that it is cost-efficient.

4.3 Summary of Recommendations

The central theme of a programme to identify and remediate Irish homes with radon concentrations above the national Reference Level is the provision of targeted information that will allow individuals to make informed choices. The specific initiatives that should be considered include

- A high profile information and media campaign to be managed jointly by the RPII, the Department of the Environment, Heritage and Local Government and the Department of Health and Children;

- A study to be commissioned on the feasibility of including radon measurement and remediation in the conveyancing process;

- Improved implementation of the building regulations to further reduce radon concentrations in newly built homes and the number of such homes with radon concentrations above the Reference Level;

- The Homebond scheme to be extended to include the installation of radon barriers and sumps;

- A programme of free radon measurements in all High Radon Areas; and

- Some form of financial assistance to householders for the reduction of radon concentrations above the Reference Level.
## Appendix 1

Results of Radon Measurements in Houses (1992-2005)

(Compiled 12th August 2005)

<table>
<thead>
<tr>
<th>County</th>
<th>Houses Measured</th>
<th>Radon Concentration (Bq/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-91</td>
</tr>
<tr>
<td>Carlow</td>
<td>514</td>
<td>263</td>
</tr>
<tr>
<td>Cavan</td>
<td>304</td>
<td>250</td>
</tr>
<tr>
<td>Clare</td>
<td>1522</td>
<td>1021</td>
</tr>
<tr>
<td>Cork</td>
<td>3104</td>
<td>2197</td>
</tr>
<tr>
<td>Donegal</td>
<td>918</td>
<td>715</td>
</tr>
<tr>
<td>Dublin</td>
<td>1585</td>
<td>1116</td>
</tr>
<tr>
<td>Galway</td>
<td>3632</td>
<td>2103</td>
</tr>
<tr>
<td>Kerry</td>
<td>2494</td>
<td>1871</td>
</tr>
<tr>
<td>Kildare</td>
<td>788</td>
<td>570</td>
</tr>
<tr>
<td>Kilkenny</td>
<td>623</td>
<td>402</td>
</tr>
<tr>
<td>Laois</td>
<td>432</td>
<td>333</td>
</tr>
<tr>
<td>Leitrim</td>
<td>249</td>
<td>203</td>
</tr>
<tr>
<td>Limerick</td>
<td>843</td>
<td>642</td>
</tr>
<tr>
<td>Longford</td>
<td>210</td>
<td>160</td>
</tr>
<tr>
<td>County</td>
<td>Louth</td>
<td>Mayo</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td></td>
<td>418</td>
<td>233</td>
</tr>
<tr>
<td>Mayo</td>
<td>2585</td>
<td>1626</td>
</tr>
<tr>
<td>Meath</td>
<td>509</td>
<td>340</td>
</tr>
<tr>
<td>Monaghan</td>
<td>208</td>
<td>158</td>
</tr>
<tr>
<td>Offaly</td>
<td>369</td>
<td>309</td>
</tr>
<tr>
<td>Roscommon</td>
<td>434</td>
<td>315</td>
</tr>
<tr>
<td>Sligo</td>
<td>1040</td>
<td>508</td>
</tr>
<tr>
<td>Tipperary</td>
<td>1248</td>
<td>895</td>
</tr>
<tr>
<td>Waterford</td>
<td>631</td>
<td>349</td>
</tr>
<tr>
<td>Wexford</td>
<td>992</td>
<td>627</td>
</tr>
<tr>
<td>Westmeath</td>
<td>421</td>
<td>271</td>
</tr>
<tr>
<td>Wicklow</td>
<td>1187</td>
<td>623</td>
</tr>
<tr>
<td>TOTAL</td>
<td>27260</td>
<td>18100</td>
</tr>
</tbody>
</table>
### Appendix 2

**Local Authority Initiatives on Radon**

<table>
<thead>
<tr>
<th>Local Authority</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlow</td>
<td>Currently compliance is required with building regulations for new housing.</td>
</tr>
<tr>
<td>Cork City</td>
<td>Offer to have link to RPII website and to display promotional material in their offices; all new buildings comply with 1997 amending building regulations; preparing a programme to monitor radon in Cork CC buildings.</td>
</tr>
<tr>
<td>Cork County</td>
<td>Offer to have link to RPII website and to display promotional material in their offices.</td>
</tr>
<tr>
<td>Dublin County</td>
<td>Radon was raised at the Environment Strategic Policy Committee meeting in February 2005 and it was decided to include information in an Environmental Awareness Information Pack.</td>
</tr>
<tr>
<td>Dublin – South</td>
<td>All Council houses built since July 1998 are fully compliant with the Building Regulations. Prepared to consider further testing of their housing stock. Further advice requested from RPII, including on remediation.</td>
</tr>
<tr>
<td>Kerry</td>
<td>Council offices and a selection of local authority houses in High Radon Areas have been measured for radon. RPII brochures on radon in homes and in workplaces are available in public offices and libraries. Kerry CC also proactively encourages coverage of the radon issue in the local media.</td>
</tr>
<tr>
<td>Kilkenny</td>
<td>Radon measurements are presently being made in Kilkenny CC workplaces; plans are being prepared to test a cross-section of new and existing council houses for radon; radon information is available online.</td>
</tr>
<tr>
<td>Offaly</td>
<td>All council offices have been measured for radon. RPII brochures will be made available in the council offices and on their website.</td>
</tr>
<tr>
<td>Tipperary North</td>
<td>Radon is addressed in 2005-2009 Corporate Plan. For 2005, a target of 12-15% inspection rate of buildings under construction has been set and is presently on target.</td>
</tr>
</tbody>
</table>