Radon potential map of the UK – updating and implementation

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Radon comes from the ground

- The main source of radon in the UK is the ground
- Building materials are *not* a significant source and most households have public water supplies
- Small changes in geology (and differences in heating, ventilation, occupancy, usage and settlement) mean that every building is unique – radon levels sometimes vary by orders of magnitude between neighbours
- Only a measurement will show the radon level in a particular building, but we can predict the *radon potential*
Long-term integrated radon measurements are used for mapping

- Radon is measured with passive radon detectors for 3 months (at all times of year)
- A seasonal correction is applied to estimate annual average
- The detectors contain PADC plastic material enclosed in a black plastic holder
- Radon damages the surface of the PADC plastic, which is made visible by chemical etching
- A standard measurement for a house uses 1 detector in a living room and 1 detector in a bedroom
- [Workplaces require many radon detectors and their results are not included in UK maps]
Radon maps from national survey in 1980s

- Radon was mapped on the basis of observation (arithmetic mean) and 10 km grid squares
- Mapping radon levels in homes showed the distribution of high radon levels
- Focus on population-weighted surveys left large areas unmapped
- Additional regional survey covered areas of geological interest
- Average UK radon level was 20 Bq m$^{-3}$
- Action Level for homes set at 400 Bq m$^{-3}$ (annual average)
The Action Level was lowered in 1990 to 200 Bq m\(^{-3}\).

The concept of Affected Areas was created, i.e. *Parts of the country with at least 1% of present and future homes being above the Action Level*.

The first Affected Areas declared in southwest England.

Statistical analysis of radon results in homes and smoothed ‘free form’ areas.
Average concentrations to Affected Areas

- Knowing only the average radon concentration does not tell you whether you are in a radon Affected Area.
- To estimate the percentage of houses above the Action Level (200 Bq m\(^{-3}\)) requires transformation of the data by taking the log value of each radon concentration.
- This produces a bell curve (approximately) where you can calculate the mean and standard deviation… the geometric mean (GM) and geometric standard deviation (GSD).
Scotland declared Affected Areas in 1993
Building regulations linked to Affected Areas

Recommendations were made with the first Affected Areas in 1990:

- **Within Affected Areas, localities should be limited for precautions against radon in future homes**
- **Government authorities should decide whether all homes [in Affected Areas] should be constructed with precautions against radon or constructed in the ordinary way, tested for high levels, and remedied if necessary**
- **Homes with precautions against radon should be constructed in accordance with approved guidance issued by the appropriate Government authorities. Compliance with the guidance should offer reasonable assurance that concentrations are as low as reasonably practicable and at least below the Action Level**

The Building Regulations are applied across the UK in 2022 (see BRE Report BR211 (2015) Radon: Protective measures for new buildings):

- **Full measures should be installed in new homes and workplaces where at least 10 per cent of homes are expected to exceed the radon Action Level. Basic measures should be installed where the radon potential exceeds 1 per cent (Scotland and Northern Ireland) or 3 per cent (England and Wales).**
- **Approved Document C - Site preparation and resistance to contaminants and moisture (2004 Edition incorporating 2010 and 2013 amendments) para 2.39-2.40:**
  https://www.planningportal.co.uk/info/200135/approved_documents/65/part_c_-_site_preparation_and_resistance_to_contaminants_and_moisture
Completing the first national map

1990s

Geometric Mean Radon Concentration

Bq m\(^{-3}\)

- **> 100**
- **75 - 100**
- **50 - 75**
- **25 - 50**
- **< 25**

- An extensive programme of Government-funded measurements was started to ‘fill in the gaps’ and produce a complete national map
- Some areas could not be mapped as there were few or no houses
- Various colour schemes were used, depending on the publication…
A revised Affected Area map was produced for England and Wales

- The map had a resolution of 5 km Ordnance Survey grid squares for most parts, with 1 km resolution for southwest England (owing to the large number of measurements following the first Affected Areas)
- Methods were applied to smooth the data, normalise by house type, and remove the contribution from outdoor air (~4 Bq m\(^{-3}\))

Ref: BMR Green et al. Radon Atlas of England and Wales, NRPB-W26

J Miles. Mapping radon-prone areas by lognormal modelling of house radon data. Health Physics March 1998 Vol 74 No 3
Similar maps were produced for Scotland…

- Deriving Affected Areas is difficult in regions with low population and few radon measurements

[Map showing percentage of homes above action level]

The Northern Ireland map is on the Irish grid and was produced for the Northern Ireland Environment Agency.


https://www.ukradon.org/cms/assets/gfx/content/resource_2700csf1b0775946.pdf
What about geology?

- The main source of radon in the UK is the ground (geology).
- Minor sources include building materials (not a problem in the UK), drinking water (private supplies) and natural gas (methane).
- Changes in geology do not coincide with grid squares…
- A new method was devised that took into account the geological units as well as the radon measurements in homes: joint data set (JDS) mapping.
- JDS mapping enables an estimate of the percentage of homes above the Action Level even when there are few or no radon measurements in the grid square, by using the results from measurements on the same geology elsewhere.
- JDS mapping also enables maps to be produced at much higher resolution: 25 metres.
- However, the resolution means that paper maps cannot show the detail in many areas.

Ref: JCH Miles and JD Appleton. Mapping variation in radon potential both between and within geological units. Journal of Radiological Protection Vol 25 pp 257-76.
All the UK radon potential maps were updated to the JDS methodology, based on measurements in almost 500,000 homes and the underlying geology.

The indicative printed map shows the highest (worst case) radon potential in each 1 km grid square; the 1600 25-metre squares in each 1 km may have a variety of radon potentials.


## Comparison between the updated GB map and previous maps

<table>
<thead>
<tr>
<th>Map</th>
<th>Number of measurements</th>
<th>Number of geological classifications</th>
<th>Number of measurements per geological classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>England and Wales (2007)</td>
<td>460,000</td>
<td>1,434</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Scotland (2011)</td>
<td>19,000</td>
<td>798</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Updated GB (2022)</td>
<td>560,000</td>
<td>9,323</td>
<td>≥ 30 (UKHSA)</td>
</tr>
</tbody>
</table>

*Note: The number of measurements per geological classification may vary depending on the dataset.*

<30 (BGS)
Buffer effect
New colour scheme

• Increase accessibility

• Reinforce message that <1% Affected Areas are mapped (no ‘white’ areas)

• Easy differentiation between generations of maps

• Northern Ireland colours changing for consistency – data remain the same
Advice – remains unchanged

• Six probability bands – same ranges
• ≥1% radon potential are Affected Areas (25 metre Ordnance Survey grid squares)
• Building Regulations still apply at 10%+ for full preventive works and 1% or 3% for basic preventive works (depending on location) – new buildings and extensions
• All basements/cellars, etc considered at risk of elevated radon levels no matter Affected Area status
• Information available on www.ukradon.org for householders, landlords and employers
• Large portfolios of properties can be assessed for radon potential
Quantitative changes in Great Britain*

- England
  - 3% increase in homes in AA’s
  - 2% increase in 3-10% bandings – basic protection range
  - Slight increase in >10% bandings – full protection range

- Wales
  - 4% drop in homes in AA’s
  - 6% drop in 3-10% bandings – basic protection range
  - Slight increase in >10% bandings – full protection range

- Scotland
  - 2% increase in homes in AA’s
  - 1% increase in 1-10% bandings – basic protection range
  - 1% increase in 10-30% bandings – full protection range

* Statistics derived from current address list for GB – will alter slightly prior to publication
Launching a new radon map is a major event
Communicating change

- Regular meetings of radon and radiation stakeholders were used to give prior notice of a new radon map in 2022
- FAQs and answers were prepared to respond to queries from householders, landlords, employers, local government, professional organisations, etc
- A press release was issued with the updated map
- E-mail lists were used by UKHSA Communications Team to alert professional organisations in health, environment, property
- Information for e-newsletters was provided to professional organisations
- Cross-Government networks were sent information and invited to meetings
- Publications will appear in professional and scientific journals
- Social media posts (Twitter, etc) linking to the new map (and responses)
- Monitoring national and local news media
Radon map shows parts of UK with highest exposure risks

The UK Health Security Agency recommends that home owners, landlords and business owners test levels of radon if they fall in an affected area.

An updated map showing the areas in the UK most affected by radon has been published by the UK Health Security Agency (UKHSA) and the British Geological Survey (BGS). Radon is a colourless and odourless gas formed by the radioactive decay of small amounts of uranium that occur in all rock and soil.

It is estimated that 1,000 lung cancer deaths a year in the United Kingdom. The risk is highest among smokers and ex-smokers. For most people, the risk of developing lung cancer from exposure to radon remains low and levels of radon have not increased across the United Kingdom.

However, UKHSA advise you to test your home if you live in an affected area. There are several methods of reducing high radon levels in buildings. The interactive map appears to show a higher concentration of potential radon exposure in parts of Wales, compared to other areas in the UK.

Radon advice: Visit our website to find out more information about radon testing and radon risk, and what you can do to reduce radon in your home.
Conclusions

1) Many radon maps have been produced since the national survey in the 1980s
2) Each iteration has seen a development in the mapping methodology as well as an increase in the number of radon measurements in homes
3) The radon Affected Area concept was introduced to highlight areas where the radon potential was greatest, i.e. the percentage of houses over the Action Level (and also where the highest radon levels were likely to be found)
4) Radon potential maps feed through to other regulations and guidance
5) The latest GB radon map is based on radon measurements in 560,000 homes and geology
6) GB was re-mapped; NI re-coloured for consistency
7) Communications and publication of the updated map were detailed and complicated
8) Effect on radon measurement numbers and www.ukradon.org will be monitored and assessed