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Nordic Radiation and Nuclear Safety Series

Overview of radon management in the Nordic countries

Report from working group Nordic-Nat

The Radiation Safety Authorities in Denmark, Finland, Iceland, Norway and Sweden

Overview of radon management in the Nordic countries

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Authors:

Ingvild Engen Finne, Maria Larsson, Bård Olsen, Norwegian Radiation and Nuclear Safety Authority (DSA), Norway

David Ulfbeck, Mie Wiese, Danish Health Authority, Radiation Protection (SIS), Denmark

Päivi Kurttio, Katja Kojo, Olli Holmgren, Tuukka Turtiainen, Radiation and Nuclear Safety Authority (STUK), Finland

Gísli Jónsson, Icelandic Radiation Safety Authority (GR), Iceland

Cecilia Jelinek, Jens Jensen, Larisa Mileshina, Swedish Radiation Safety Authority (SSM), Sweden

Swedish Radiation Safety Authority SSM
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Summary

The aim of this document has been to make an overview of radon management and have a closer look at the similarities and differences between the Nordic countries in this matter. The document is not exhaustive but will be useful for the Nordic co-operation and serves as a basis for further discussions and work to achieve our goals given in the mandate of the Nordic-Nat group.

When comparing typical radon activity concentrations e.g. in dwellings, drinking water, etc. it can be seen that the challenges are relatively similar in Finland, Norway and Sweden. Denmark has a less widespread problem, and the radon activity concentrations are generally lower, but the problem is definitely present. In Iceland several national surveys have shown that the radon activity concentrations both in indoor air and drinking water are overall very low.

However, comparisons between surveys or individually measured buildings in the different countries must be made with caution. That is one of the reasons that this document will be very useful. For instance, this study has shown that the measurement procedures vary between the Nordic countries. One example is that the seasonal correction factor varies between 0.75 and 1 (no correction). Further, the reference level in Denmark and Sweden refers to an average of measurements in the dwelling, while in Norway it refers to each single living- and bedroom. In Finland, the radon activity concentration in dwellings was reported as the average of the measurement results according to the housing health guidelines until 2016. At that time, the application guide for housing health legislation was updated, in which radon was no longer mentioned. In practice, the outdated guideline has still been in use.

The reference level for existing dwellings and premises where the public have access varies between 100 and 300 Bq/m^3 and limit/reference values in new buildings between 100 and 200 Bq/m^3. Norway differs from the other countries in having a two-part system of reference values.

Further, there are differences between the countries in how long the limit/reference values given in the national building regulations for a new building apply. In Denmark it applies as long as the building exists, and consequently all buildings constructed according to the provisions in Building Regulations 2010 or later are subject to the limit value of 100 Bq/m^3. In Finland, the reference value for new buildings is usually valid for 10 years after completion. In Norway the regulations apply until the certificate of completion is issued, but with a general warranty period of 5 years. In Sweden, the requirement must be met in such a way that with normal maintenance the requirement can be assumed to continue to be met for an economically reasonable lifetime of the building, in accordance with 8 chapter, 5 section 2 item in the Planning and Building Act (SFS, 2010:900). Should the requirement become stricter in the future for new buildings, you cannot be obliged to upgrade the building.

In addition to the limit value, solutions for preventive measures in new buildings are mandatory and specifically mentioned in the regulation in Norway. In Denmark, Finland and Sweden, the limit/reference values are given in the regulations, and guidance material is provided on how to fulfil the regulatory limit values by means of preventive measures.

In Sweden, the national grants for radon remediation in dwellings that were offered by the authorities in two periodes, 1988-2015 and 2018-2021 have been discontinued. The general tax deduction for craftsman services in private dwellings still exists. Similar general tax deductions are offered in Finland. In Denmark the tax deduction option for costs related to radon mitigation measures in existing dwellings, was abolished in April 2022. In Norway no grants or tax deductions are offered.

Denmark, Finland and Sweden all have reference levels and/or limit values for workplaces stated in national regulations. In Norway the workplace is regulated in general terms in the regulations and reference values are given in guidance material.

When it comes to drinking water the recommendations and requirements also differ between the countries. For waterworks the quality requirements of radon activity concentration are either 100 or 1000 Bq/L. The countries with the highest quality requirements levels have a quality target value of 100 or 300 Bq/L. For private wells there are no requirements, but the quality recommendations vary between 500 and 1000 Bq/L.

Finland, Denmark and Sweden have implemented reference levels for doses caused by gamma radiation in new buildings and building materials in the national regulations. In Norway gamma radiation in buildings and building material is not regulated.

Content

Introduction

The Nordic Working Group on Natural Ionizing Radiation (Nordic-Nat) consists of Radiation and Nuclear Safety Authority (STUK, Finland), Swedish Radiation Safety Authority (SSM), Danish Health Authority, Radiation Protection (SIS), Icelandic Radiation Safety Authority (GR) and Norwegian Radiation and Nuclear Safety Authority (DSA).

At the Nordic-Nat workshop in Oslo, January 2019, the first Work Programme of the group was formed. One of the tasks was to make an overview of radon management in the Nordic countries, which this document intends to do.

In addition to an overview of radon activity concentrations, reference levels and limit values in dwellings, workplaces and other buildings to which the public has access, reference levels and limit values for drinking water, gamma radiation in new buildings and building material are included to give a comprehensive picture of the management in the field of radon/natural radiation.

When reading this document, it may be useful to keep in mind that Denmark, Finland and Sweden are EU state members, and the Council Directive 2013/59/Euratom (EU BSSD) (EU, 2013) and Council Directive 2013/51/Euratom (radioactive substances in drinking water) (EU, 2013) have been adopted and implemented in these countries. However, Norway and Iceland are not members of the EU, and not bound by the Euratom directives.

An essential part of the EU BSSD and IAEA Basic safety standards (IAEA, 2014) is the requirement and recommendation, respectively, for a national radon action plan. Several topics required in an action plan are covered in this document, but not the action plans as such. Links and brief information on the Nordic radon action plans are provided in appendix 1, measuring protocols and other relevant protocols and guidance materials are refered to in appendix 2 and 3 respectively. In addition, appendix 4 gives an overview over relevant legislation.

The bedrock in Iceland is mostly young, primarily basaltic and is known to have very low concentrations of uranium and thorium. Surveys carried out in Iceland show very low radon activity concentrations both in air and water. For this reason, Iceland does not have reference levels or limit values for radon. Iceland is consequently not included in the overviews given in this document, except for in chapter 1, National average radon concentrations.

The document is primarily designed to provide a brief comparison of radon management in the Nordic countries. The document is intended for (but not limited to) internal use in Nordic-Nat to achieve our goals given in the mandate of the group.

1. National average radon activity concentrations

	Denmark	Finland	Iceland	Norway	Sweden	
Dwellings (Bq/m^3)	77 [1)]	94 [3)]	5-13	88 [8)]		Arithmetic mean 90 [11)] 124 [12)] 68 [13)]
Workplaces (Bq/m^3)		33 (19) [4)]			Median 79 [14)]	Arithmetic mean 106 [14)]
Drinking water (Bq/L)	~ 1 Bq/L [2)]	30 [5)] 38 (12) [6)] 311 (138) [7)]	1.6-1.9	78 [9)] 90 [10a)] 400 [10b)]	Median 12-20 [15)] 37 [16)] 150 [17)]	Arithmetic mean 17 – 23 [15)] 101 [16)] 317 [17)]

1) Arithmetic mean, based on approximately 3000 measurements in single family houses. Mean value weighted according to population density. Geometric mean (weighted) 57 Bq/m^3. Data from 2001. Data from dwellings in apartment complexes (approximately 300 dwellings) have average radon concentrations approximately 2 times lower or less. Data from 2001 (Andersen et al. 2001) and 2015 (Rasmussen & Skytte Clausen, 2016).

2) Average radon concentrations in drinking water on the island of Bornholm are in general elevated and in the range of 1-65 Bq/L.

3) Arithmetic mean. The average effective dose of Finns in 2018 (Siiskonen (ed.), 2020).

4) Arithmetic (and geometric) mean during working hours. (Kojo et al., 2023).

5) Geometric mean in water distributed by waterworks. Data on 1481 samples collected in 2016–2021 (Turtiainen et al., 2019 and Turtiainen et al., 2022)

6) Arithmetic mean: (and median) in dug wells based on 667 samples collected in 1999 (Korkka-Niemi et al., 2003),

7) Arithmetic mean (and median) in drilled wells based on 252 samples collected in 1999 (Korkka-Niemi et al., 2003)

8) Based on approximately 29 000 measurements performed in 114 of the 435 Norwegian municipalities in 2000-2001.

9) Waterworks – bedrock, estimated arithmetic mean based on 29 samples in 1996

10) Estimates based on 3500 samples, not randomly selected, private groundwater sources (mainly supplying single households) measured in in 1996-98.
   - a) Drift geology
   - b) Bedrock

11) Population-weighted arithmetic mean based on radon activity concentration measurements in the BETSI project 2007-2008 involving about 1800 apartments and detached houses (Barregård, 2012). The analysis is based on population in different parts of Sweden.

12) Arithmetic mean in detached houses based on radon measurements in the BETSI project 2007-2008 involving about 1800 apartments and detached houses. Number of the measured detached houses corresponds to 1.9 million detached houses in Sweden (Boverket, 2010).

13) Arithmetic mean in apartment buildings based on radon measurements in the BETSI project 2007-2008 involving about 1800 apartments and detached houses. Number of the measured apartment buildings corresponds to 2.4 million apartments in Sweden (Boverket, 2010).

14) The mean and arithmetic values are based on data from 3347 workplaces for different workplace types. Measurements are made with Radtrak^2-detectors and values are not corrected for working hours (Rönnqvist, 2021).

15) Waterworks: For large and small waterworks based on 375 measurements (Kulich et al., 1988).

16) Dug wells: Values based on 4104 measurements, not randomly selected, in the database of the Geological Survey of Sweden, 1.2% above 1000 Bq/L (SGU, 2024).

17) Drilled wells: Values based on 24 689 measurements, not randomly selected, in the database of the Geological Survey of Sweden, 5.9% above 1000 Bq/L (SGU, 2024).

Denmark: The most recent national survey on radon activity concentrations in Danish dwellings includes data primarily generated in 1995 and published in 2001 (Andersen et al. 2001). Prior to that, less elaborate studies were conducted in 1987. In the years 2005-2007, a thematic study focused on the effects of updating building regulation requirements, and in 2016 a survey on radon activity concentrations in multi-story apartment complexes were conducted (Rasmussen & Skytte Clausen, 2016). In 2015-2020, indoor radon activity concentration data collected through a privately organised survey campaign including approximately 17000 dwellings was used to evaluate the effectiveness of implementation of the building regulation requirements. The overall outcome of the study was that building regulations are complied with and have an effect. The study further demonstrates overall agreement with the outcomes of previously conducted surveys, but in addition concludes that a significant fraction of new-build dwellings have radon levels exceeding national values in national building regulations (Rasmussen, 2022).

Finland: A national survey of radon in indoor air of dwellings was conducted in 2006 (Mäkeläinen et al., 2009). Radon activity concentration was measured in 2882 randomly selected dwellings. The nationwide means (weighted by number of inhabitants in provinces) were 121 Bq/m^3 in houses and 49 Bq/m^3 in flats, and 96 Bq/m^3 for all dwellings. In a recent estimation of public exposure to indoor radon, the radon activity concentration for all dwellings (96 Bq/m^3 from the 2006 survey) was adjusted using recent information on proportion of inhabitants living in flats versus houses. This adjustment was necessary because in 2006, 34% of the population lived in flats, whereas by 2018, this proportion had increased to 37%.

The most recent study of newly built houses was conducted in 2016. Radon activity concentration was measured in 1332 randomly selected newly built houses, where the mean (and the median) radon activity concentration was 71 (42) Bq/m^3 (Kojo et al., 2016).

STUK maintains a national radon database both for dwellings and workplaces, with approximately 221 000 measurements in dwellings and 124 000 in workplaces (Oct 2023). Most of the results for dwellings come from voluntary measurements made by residents. Some results are from random selection, or focused surveys, or other studies. All measurement results from dwellings are from STUK's own radon measurement laboratory. Most of the results for workplaces come from statutory measurement made by employers. The workplace database contains results from both STUK's own radon laboratory and private measurement laboratories.

The results of the latest survey of radon activity concentrations in workplaces were published in 2023. The survey included radon measurements from 700 workplaces that participated voluntarily. Using deterministic methods, the geometric and arithmetic mean radon activity concentrations in conventional, above-ground workplaces were 41 and 91 Bq/m^3, respectively. The estimated geometric and arithmetic mean annual radon activity concentrations that Finnish workers are exposed to during work were assessed as 19 and 33 Bq/m^3, respectively. Using probabilistic assessment, approximately 34 000 workers in Finland are exposed to radon levels exceeding the reference level of 300 Bq/m^3.

The latest survey covering private wells was conducted in 2000–2001. In total, 472 water samples were analysed (U-238, U-234, Ra-226, Rn-222, Pb-210 and Po-210). Following the implementation of Council Directive 2013/51/Euratom into national legislation in 2015, results from the sampling regime on radon and indicative dose are summarised every three years. The latest summary covers the period 2019–2021 (Turtiainen et al. 2022). In the 2023 update of the Drinking Water Decree, it was stated that it is no longer necessary to continue the summaries due to the low radon concentrations.

Iceland: Three surveys of radon in indoor air have been made in Iceland in the years 1982, 2003 and 2012. All surveys showed low average activity concentration (5-11 Bq/m^3) and no measurements was above 80 Bq/m^3. The latest survey in 2012 was made in 250 households and the mean radon value was 13 Bq/m3 (median 9 Bq/m^3). The distribution of the results is heavily biased towards the lower values with large portion of the results at or below the minimum detectable activity, 95% of the results below 40 Bq/m^3 and the highest value is 79 Bq/m^3.

Radon in drinking water has also been surveyed in Iceland in 2014-2015 and 2016-2019 with mean value 1.6 Bq/L and 1.9 Bq/L respectively and no sample measured showed values above 20 Bq/L.

Norway: DSA holds a national database for radon in indoor air with approximately 135 000 measurements. The origin of most of the measurement results are from DSA´s surveys. Some are random selection surveys of radon in dwellings. Others are focused surveys, such as surveys of new buildings and dwellings where remediation have been implemented. The database also contains a large part of results from private measurement laboratories shared with DSA. Based on approximately 29 000 measurements in 2000-2001 the average radon activity concentration in Norwegian dwellings were estimated to 88 Bq/m^3 (Strand et al., 2001).

Approximately 82% of the Norwegian population get their water from surface water. The rest get their water from groundwater sources, and it has been estimated that approximately 9% from public waterworks and 9% from private wells. The share of drift and bedrock geology among the private wells is highly uncertain, but based on current assumptions, the estimated population weighted average for all drinking water sources in Norway is 38 Bq/L, heavily affected by higher radon activity concentrations in water from private wells drilled in bedrock (Komperød et al., 2015).

Sweden:
The latest statistically controlled study on radon in indoor dwellings was conducted 2007-2008 by the Swedish National Board of Housing, Building and Planning in the so-called BETSI-project (Buildings energy use, technical status and indoor environment), where a sample of about 1800 apartments and detached houses were studied. Barregård and Andersson calculated a population-weighted arithmetic mean 90 Bq/m^3 based on the radon activity concentration measurements in the BETSI-project, as well as on population in different parts of Sweden (Barregård, 2012).
The estimated arithmetic mean for detached houses 124 Bq/m^3, and for apartment buildings 68 Bq/m^3, were obtained based on the measurements in the BETSI-project (BETSI, 2010).

In 2021 a study from measurement results in the Radonova database was made, comprising 340 000 measurements in detached houses. The database contains more measurement results in areas with well-known problems of elevated radon levels and in detached houses containing blue concrete. Corrections for this were made when calculating a national mean for detached houses, the 2007/2008 measurement season was estimated at 128 Bq/m^3 and for 2008/2009 at 136 Bq/m^3 (these measurement seasons are considered most representative due to massive measurements campaigns these years). The study also concluded that the number of detached houses in 2021 with radon levels above 200 Bq/m^3 were around 330 000, representing around 16% of the total number of detached houses.

Regarding the data for drinking water, there is data from waterworks and private wells. The values (arithmetic means and median) for waterworks originate from two categories of waterworks. One set of measurements of radon activity concentrations was carried out on samples taken from 171 larger waterworks (more than 0.2 million cubic meters per year) between 1977 and 1979. Water samples for the second set of measurements were taken from 204 smaller waterworks (less than 0.2 million cubic meters per year) between 1981 and 1983. (Kulich et. al., 1988).

The data for drinking water from wells are based on samples collected from the whole of Sweden over past decades. The data includes sampling from larger water supplies, as well as private wells, springs and groundwater control pipes, the vast majority are private wells (74% of dug wells, 98% of drilled wells). Median estimations of radon activity concentrations in drinking water from dug and drilled wells are based on 4104 and 24 689 measurements respectively (SGU, 2024).

2. Radon maps

National radon maps are often structured using various methods, making it difficult to compare. The most appropriate way to compare the geographic distribution of radon in the Nordic countries is probably to use the EU Joint Research Centers (JRC) map on indoor air measurements in Europe (https://remap.jrc.ec.europa.eu/Atlas.aspx?layerID=3) where all countries have reported the available radon measurements the same way.

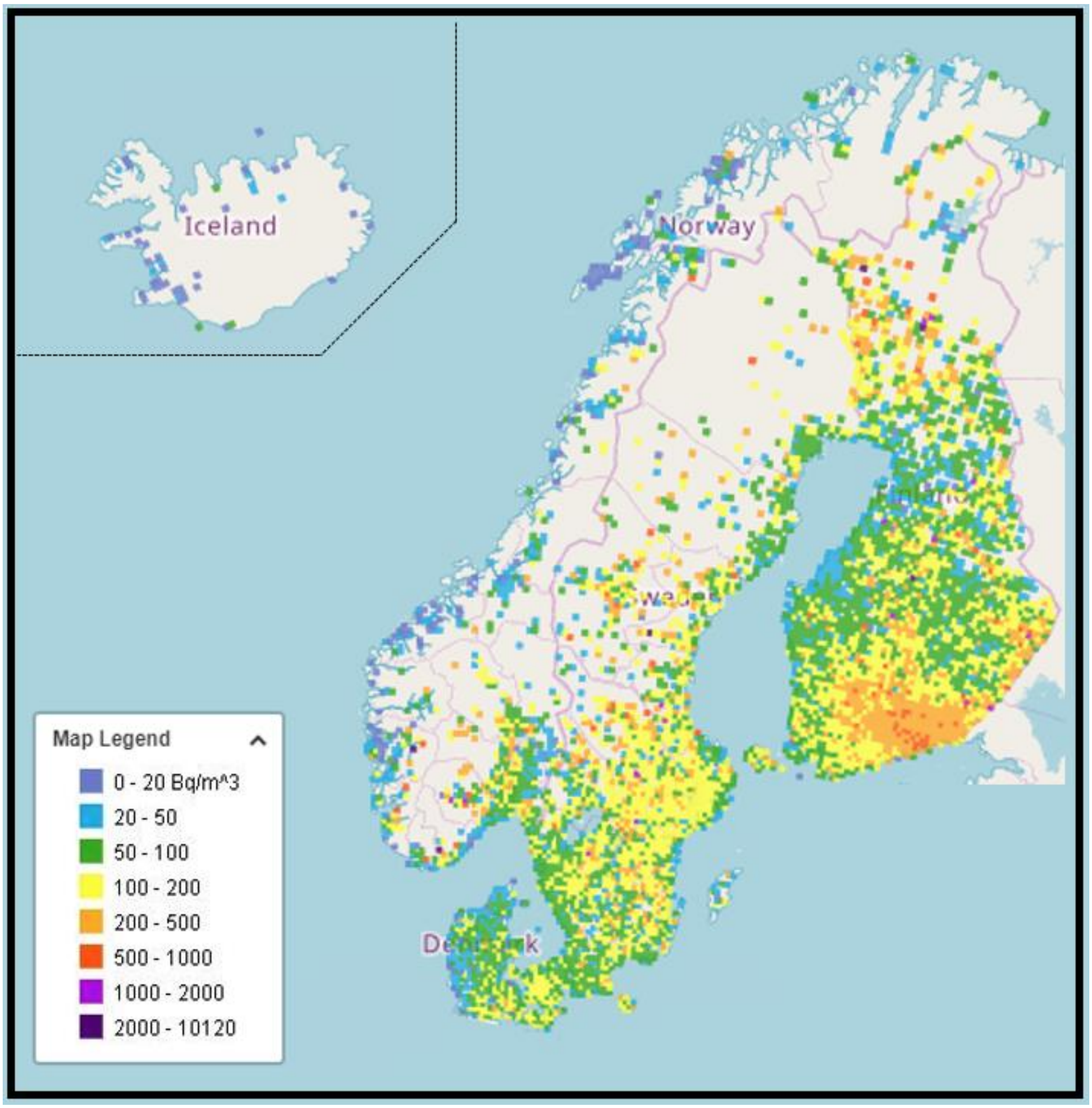
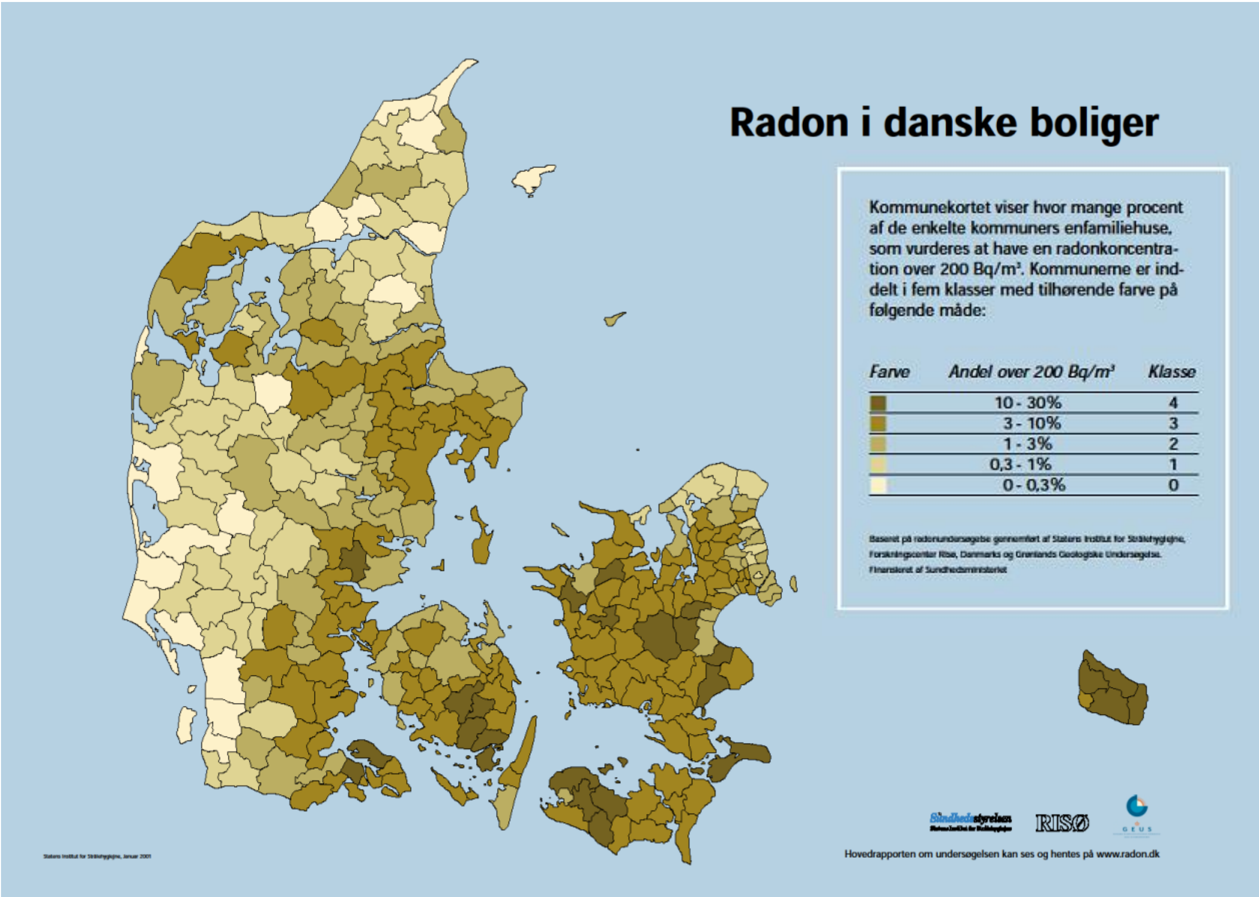


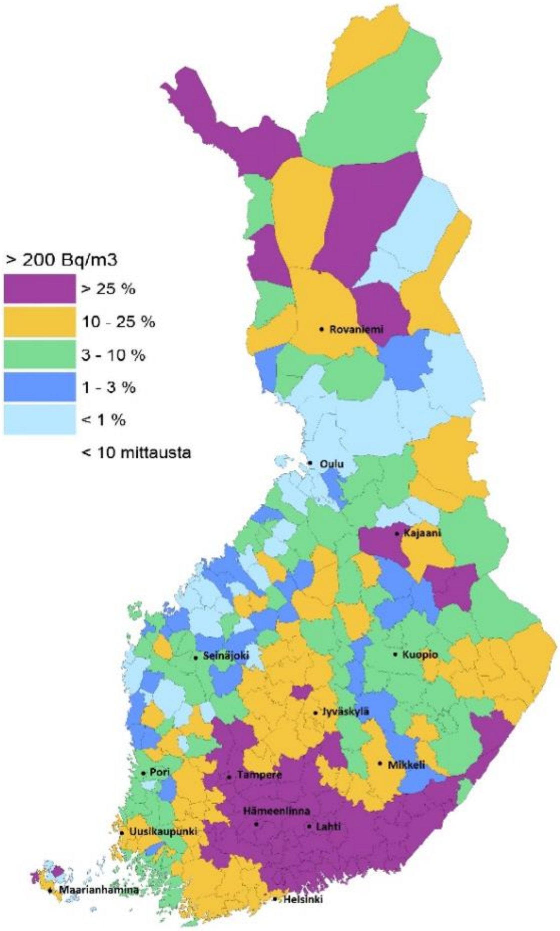
Figure composed of screenshots from the EU JRC Radon indoor map (2021).

The European Indoor Radon Map reports the arithmetic means (AM) over 10 km x 10 km grid cells of annual indoor radon activity concentration in ground-floor rooms of dwellings. The input data are provided by national competent authorities, which aggregate their original data into the grid and calculate a set of statistics per cell. As new indoor radon data arrive at the JRC from participating countries, the map is updated at irregular intervals.

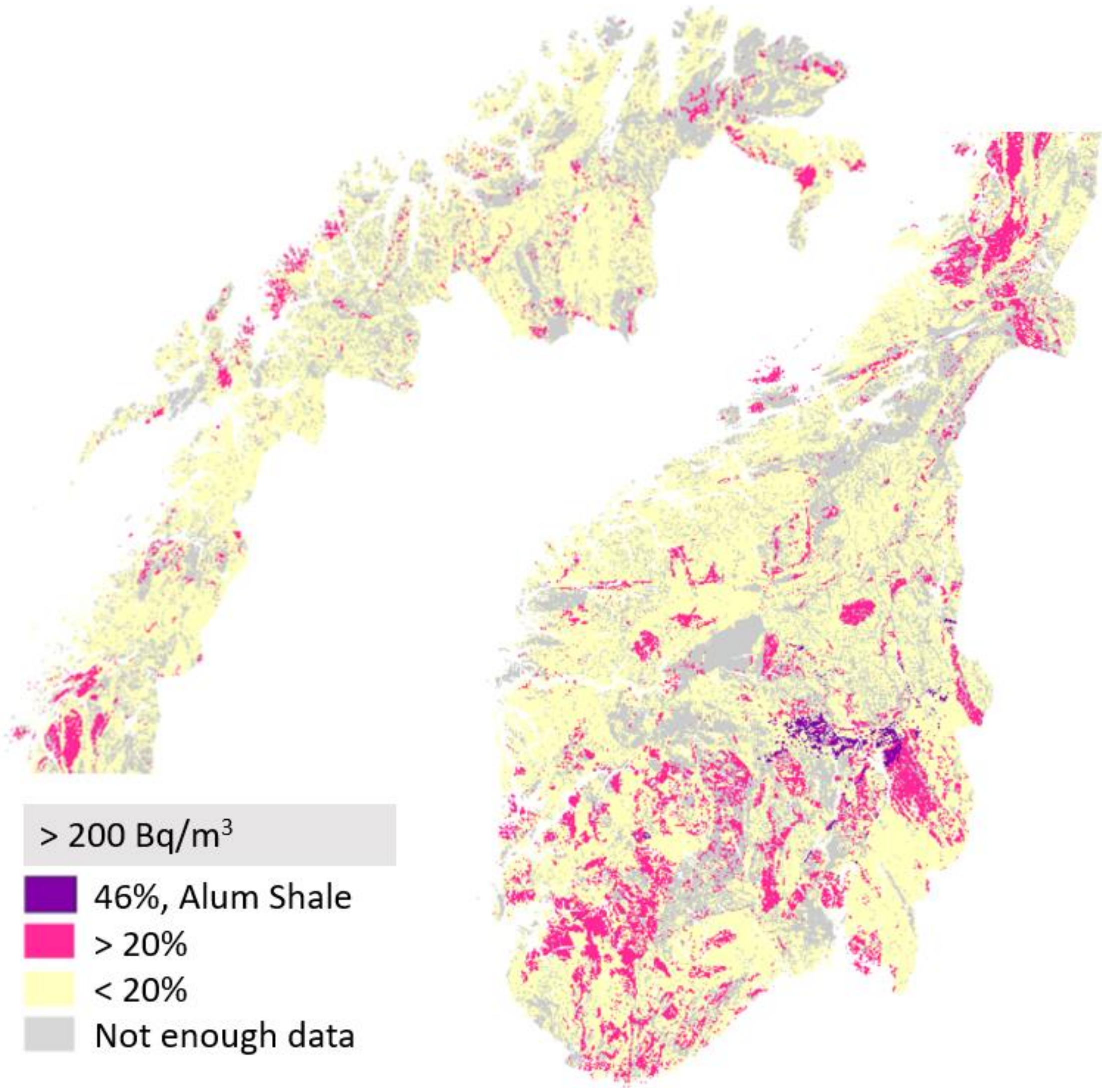
Denmark: The outcome of the national survey from 2001 is presented in a national map, displaying percentages of dwellings in each municipality with radon activity concentrations above pre-defined levels (https://www.sst.dk/-/media/Viden/Straaling/Radon_2001_kommunekort.ashx?la=da&hash=5ADE4EBBF7AF1239D1882DB1D1D01D6528435281).



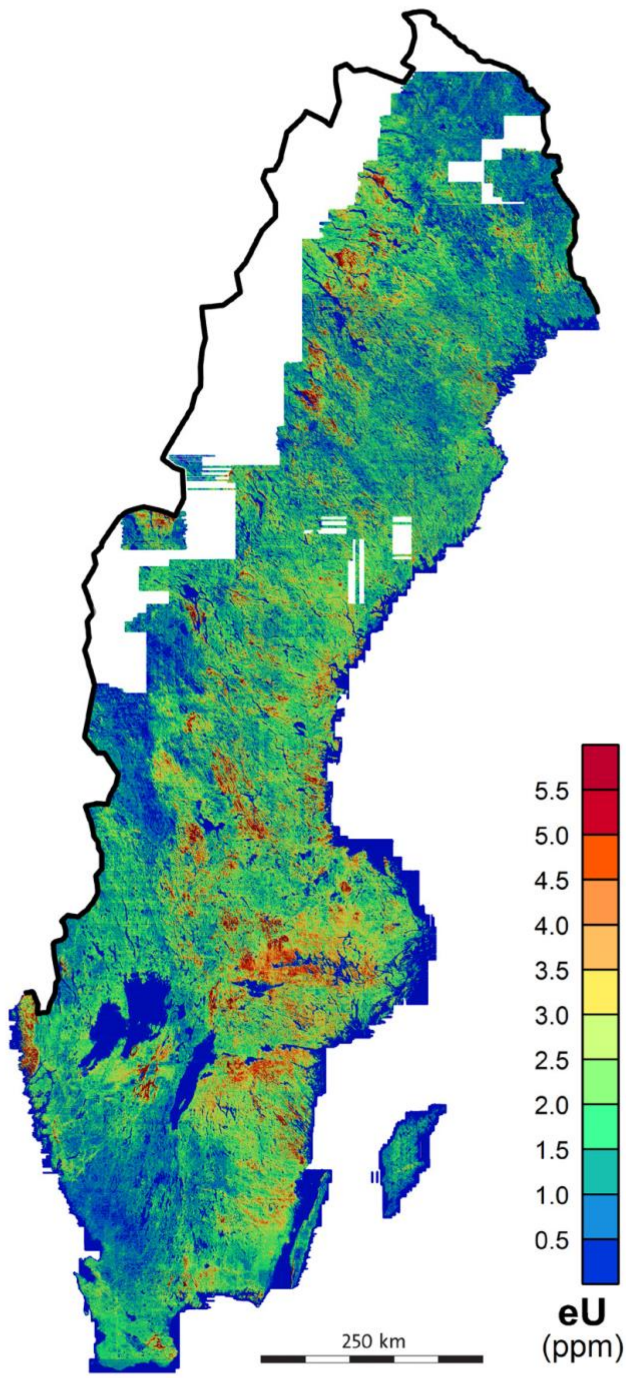
Finland: STUK has created several radon maps over time (https://stuk.fi/en/maps-of-radon-in-finland). One example is a map (2017) of Finnish municipalities showing the proportion of measured dwellings where the radon level is greater than 200 Bq/m^3.



Norway: DSA and Norwegian Geological Survey (NGU) have together created several variants of radon maps over time. The current map (2015) is predicting the proportion of dwellings with radon activity concentrations exceeding 200 Bq/m^3 based on bedrock (categorized according to typical uranium concentration), drift geology and radon indoor air measurements (http://geo.ngu.no/kart/radon_mobil/) and (Watson et al., 2017)



Sweden: In Sweden radon maps have been produced at municipal level (not for all municipalities), mostly in the early 1980s. A proper national radon map has not been produced in Sweden. The Geological Survey of Sweden (SGU) has developed maps, based on airborne gamma radiation measurements, to determine the concentration of uranium and other radioactive elements in the ground. Around 85 percent of Sweden's area has been mapped by radiometric measurements as of today. This map shows uranium concentration.



Source: SGU-report Mineralmarknad 2015, Tema energimetaller. See also the following link: https://apps.sgu.se/kartvisare/kartvisare-uranstralning.html

3. Reference levels and limit values in dwellings, rental accommodation, premises with public access, schools and kindergartens

	Denmark	Finland	Sweden	Norway
Reference level in existing dwellings and premises where the public have access	100 Bq/m^3	300 Bq/m^3	200 Bq/m^3	Action level: 100 Bq/m^3 Maximum level: 200 Bq/m^3
Limit value in new buildings	100 Bq/m^3	Reference level: 200 Bq/m^3	200 Bq/m^3	200 Bq/m^3

Denmark: The reference level on 100 Bq/m^3 is valid in all buildings, including dwellings, workplaces, public premises etc.
A limit value of 100 Bq/m^3 is valid depending on when the building is constructed, no matter the use of the building. All buildings constructed according to the provisions in Building Regulations 2010 or later are subject to the limit value of 100 Bq/m^3.

In Denmark the municipalities have an extended responsibility for ensuring safe living conditions for its inhabitants. Thus, in principle, if it should become known that indoor air quality is detrimental to health or associated with high risks thereof, the municipality may impose relocation orders and remediation actions, also in private homes. The occurrence of radon levels of such magnitude that these actions would be warranted is not documented in Denmark, nor expected to be.

Finland: The reference level of 300 Bq/m^3 applies to existing dwellings and buildings with public access. The reference level of new buildings is 200 Bq/m^3. Currently, nobody supervises compliance with the reference level for new buildings. It is more of an agreement between two contracting parties. If the reference level is exceeded, the owner can require remedial actions as warranty work or compensation. The liability period for compensation is usually 10 years.

The local health protection authority may request results on indoor radon activity concentrations and demand remediation if the concentrations are higher than the reference level in dwellings and buildings with public access (Radiation Act 158 §).

Norway: The action level is the highest annual average radon level which may be accepted before radon mitigation should be carried out. Maximum level refers to the highest annual average radon level which may be accepted in a frequently occupied room.

In schools, kindergartens and rental accommodations the action and maximum level of 100 and 200 Bq/m^3, respectively, are limit values set in the Radiation Protection Regulations.

The limit value for new buildings is set in the Building Regulations. The requirement in the technical building regulations shall be met at the time when a certificate of completion is issued by the local municipality. Anyway, within a general warranty period of 5 years the owner can require remedial action by the responsible builder of the building.

Sweden: The reference level 200 Bq/m^3 is valid in all existing buildings, including dwellings, workplaces and public premises in accordance with 3 chapter 6 section in the Radiation Protection Ordinance (2018:506).

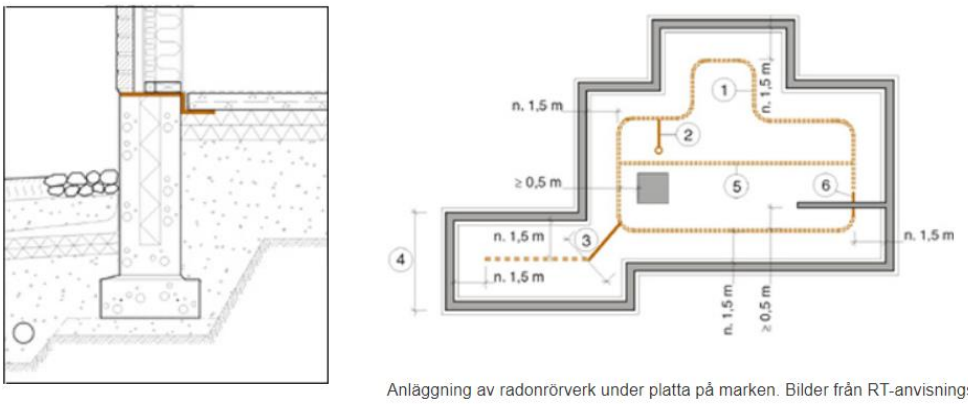
In new buildings a strict limit of 200 Bq/m^3 applies in accordance with 6 chapter 23 section in the building code (BFS, 2011:6) issued by the Swedish National Board of Housing, Building and Planning (Boverket). The requirement must be met in such a way that with normal maintenance the requirement can be assumed to continue to be met for an economically reasonable lifetime of the building, according to 8 chapter 5 section 2 item in the Planning and Building Act (SFS, 2010:900). Should the requirement become stricter in the future for new buildings, you cannot be obliged to upgrade the building. In new buildings it is possible for the municipal building board to demand and control that compliance with the limit value is fulfilled. For existing buildings, the municipal environmental and health protection board can request information about radon levels in apartment houses, schools and kindergartens as well as premises with public access in accordance with 8 chapter 2 section 3 item in the Radiation Protection Ordinance (2018:506). It is also possible for the municipal environmental and health protection board to demand radon remediation.

4. Preventive measures in new buildings

Denmark: The Danish Building regulation states that buildings must be constructed such that it ensured that the radon activity concentration does not exceed 100 Bq/m^3. The regulation contains no prescription as to how to achieve this goal, but guidance from the Danish Building Research Institute on technical measures is available (for subscribers only). The guidance available includes measures which are similar to the ones described for Norway (membranes and radon sumps).

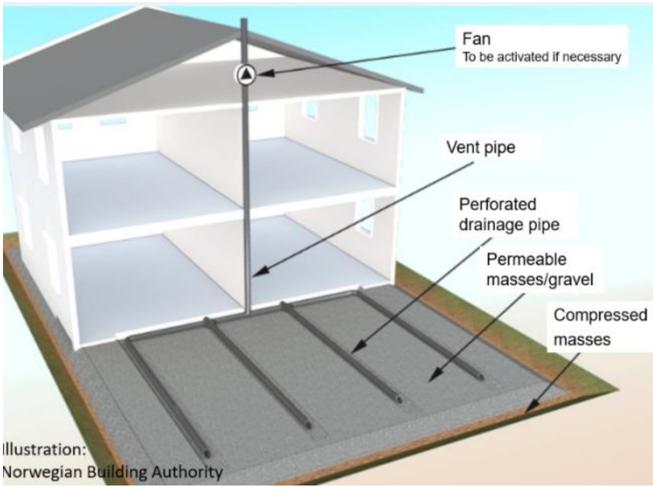
Finland: According to the National Building Code of Finland (the Decree of the Ministry of the Environment on Foundation Structures, 465/2014), the radon risks of the construction site shall be taken into consideration. This may be independently interpreted by local building authorities. According to the instructions of the decree, the adverse effects on indoor air quality from radon are prevented with structures and/or measures that are applicable to the project under design. Common practices for preventing the adverse effects of radon include sealed base floors, base floor ventilation and radon pipelines. The success of the structure and/or action on the indoor air radon activity concentration can be determined by measuring the radon activity concentration in the indoor air after the construction work or action is completed. The National Building Code of Finland: https://www.ym.fi/en-US/Land_use_and_building/Legislation_and_instructions/The_National_Building_Code_of_Finland.

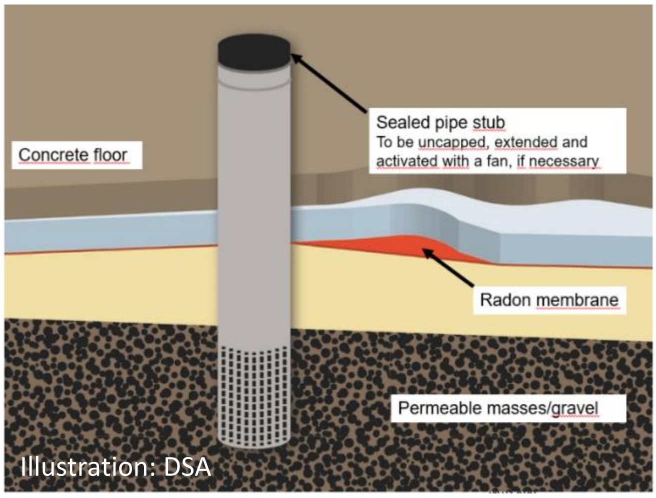
Preventive measures are sealing of the joints between the wall and floor using bitumen felt in combination with perforated drainage piping in the building ground and ventilation above the roof (see example below).



Anläggning av radonrörverk under platta på marken. Bilder från RT-anvisningskortet (RT 81-11099).

Norway: In 2010, two mandatory anti-radon measures and a legally binding limit value for indoor radon, 200 Bq/m^3, were introduced in the building regulations. The regulations apply to the entire country, no areas are excepted. The prevention measures are (with some exceptions) a radon barrier over the entire base area of the building in combination with a standby radon sump system. It is recommended to effectuate the radon sump when the radon activity concentration is above 100 Bq/m^3. The building regulations do also apply to extensive building renovations.





Both solutions showed in the illustrations are in compliance with the regulations.

Sweden: There are no detailed measures required by the building code (BFS, 2011:6) issued by the Swedish National Board of Housing, Building and Planning (Boverket). It is however advised in section 6:23 of the building code that measures to limit inward leakage of ground radon should be implemented in new buildings. Sealing of pipe penetrations in the building is an example given of such measures. It is also stated that buildings should be made as airtight as possible towards the ground to prevent inlet of radon. Different types of membranes are used. It is getting more common to place passive drainage pipes below the ground slab in a new building for possible connection later to reduce radon levels if needed. The Swedish National Board of Housing, Building and Planning suggests the following reference for guidance: The radon book – New buildings (in Swedish), (Box, 2019).

Municipalities may demand ground radon measurements prior to construction or demand a "radon-safe" construction method in the inspection plan. However, this is not regularly required by all municipalities.

Regarding remodeling of buildings, section 6:923 of the building code (BFS, 2011:6) suggests sealing of penetrations to the ground or changing the pressure conditions in the building. In case the origin of radon is a building material (blue light concrete), examples of measures can be tearing out of the material, or an increased air exchange through improvement of existing ventilation, or installation of new ventilation system, or encapsulation through a gas-tight wallpaper. The Swedish National Board of Housing, Building and Planning suggests the following reference for guidance: The radon book – Measures against radon in existing buildings (in Swedish), (Radonboken, 2020).

5. Measurement length, measurement period and seasonal correction factor

	Denmark	Finland	Norway	Sweden
Measurement length	At least 2 months	At least 2 months	At least 2 months	At least 2 months
Measurement period	1 Oct. – 30 April[1)]	1 Sept. – 31 May	15 Oct. – 15 April[1)]	1 Oct. – 30 April[1)]
Seasonal correction factor[2)]	No seasonal correction	0.9	Dwellings: 15 Oct.-31 Oct: 1 1 Nov.-31 March: 0.75 1 April-15 April: 1 No seasonal correction for big buildings with balanced ventilation	No seasonal correction
The reference levels and limit values apply to…	… an annual average for the building	… in dwellings, the average of measurement results; in premises with public access, the average concentration during use; and in workplaces, the average radon concentration during working hours in spaces where usage exceeds 600 hours annually, or the annual radon exposure.	… frequently occupied rooms, like bedrooms and living rooms.	… a dwelling as a whole, i.e. is compared to the average value which has to be based on more than one measurement in the dwelling.

1) In Denmark, Sweden and Norway 20% of the measurement time may be performed outside the specified measurement period, provided that at least 2 months are within.

2) For the calculation of annual average radon activity concentration.

Denmark: For dwellings: Reference level and limit value apply to an annual average for the building calculated from several measurements and according to a standardized method. For dwellings with one floor the average value is calculated by the measurement results from all measuring points in the housing. The number of measuring points must be at least two. For a dwelling with more than one floor the average value is first calculated for each individual floor. Subsequently, the average value of the dwelling is calculated on the basis of the average values from the respective floors.

Regarding number of rooms versus number of measurement devices, the guidance states that if there are less than 4 rooms in the house, where most of the time is spent, the number of measurement devices should correspond to the number of rooms, and at minimum be 2. If there are more than 4 rooms, the number of devices should be 4 plus 1 device per additional 3 rooms.

For other buildings than dwellings: Reference level apply to radon exposure calculated with a similar method as for dwellings, but only taking into account radon activity concentration during the actual exposure time.

Finland: For workplaces, the duration of working time spent in the workspace is considered (e.g. nomadic workers, short-duration contracts). The seasonal correction factor and optimum season for radon measurement are derived from monthly radon measurements carried out in 329 dwellings in 1996–1997 (Turtiainen et al. In: STUK-A261, 2018).

Norway: The seasonal correction factors used for dwellings in Norway are based on a nation-wide survey of approximately 7500 randomly selected dwellings distributed over a period of two years (1987-1989) (Strand T, 1995). Example of seasonal correction factor calculation is given in the measurement protocols, appendix 2 and 3.

At least two frequently occupied rooms should be measured for each dwelling, and at least one in each floor.

Seasonal correction factor is not used for schools and kindergartens with balanced ventilation systems. This is based on results from a survey (2013-2014) where measurements were performed in schools and kindergartens with balanced mechanical ventilation in periods of two months in six consecutive periods along with detectors left for one year (Kolstad et al., 2015).

Sweden: For dwellings with one floor, the average value of the measurement results is calculated from all measurement points in the dwelling. The number of measurement points must be at least two. For dwellings with more than one floor average values are first calculated for each individual floor. The average value for the whole dwelling is then calculated based on the average values from each floor.

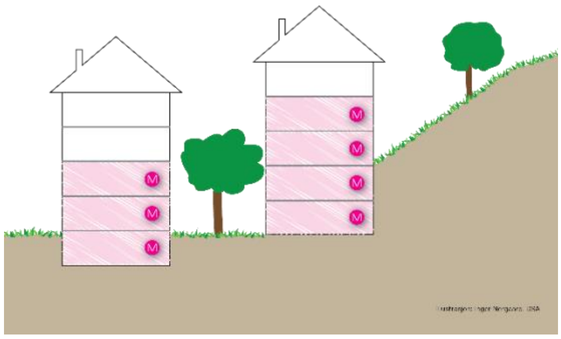
For workplaces this procedure is not applied. There, a comparison of individual measurements or calculated results with the reference level or limit values has to be performed.

6. Selection of apartments for radon measurements in apartment buildings

Denmark: It is generally evaluated that radon in apartment buildings is well below reference level (or limit value), except in few cases for floors with apartments directly in contact with the ground. Therefore, no explicit criteria for selection of apartments for radon measurements have been formulated. Nonetheless, with reference to the general guidance on radon measurements (SBi anvisning 270), the following criteria apply:
For measurements of individual dwellings in apartment buildings, the procedure is the same as for other dwellings, in terms of number of dosimeters and calculation method.
When measuring an apartment building as a whole, the recommended measurement protocol is the same as for office buildings, institutions etc., doing multiple measurements on the ground floor, the number depending on the number of rooms/apartments, and one additional set of measurements on each higher floor.

Finland: Radon measurements are done in each apartment in contact with the ground. It is not necessary to measure radon in other floors.

Norway: In apartment buildings, residents of apartments in contact with the ground, and on the floor above, are advised to measure radon. A traditional ground floor, by definition, always has ground contact, even when it is basement/crawl space below. Ground contact may also include apartments where one or more of the walls are in direct contact with the ground, for example if they are built on a slope (see illustration). It is not necessary to measure radon in apartments on other floors unless special conditions indicate so (particularly radon prone area, high radon activity concentration measured in other apartments in the building).
As an alternative the entire apartment building can be measured as a unit. Then apartments that have contact with the ground are measured, as well as a representative selection of apartments further up the floors.



Sweden: For radon activity concentration measurements in an apartment building, a selection of apartments has to be done in a way that the measurement results would give understanding about the radon situation in the whole building.

Measurements should be made in all apartments with ground contact. Ground contact means that the space is located directly on the base plate or directly above the crawl space.
Radon measurements should include apartments where the building material can be assumed to contribute to elevated radon levels.

In higher floors, measurements should be made in at least one apartment per floor, and in at least 20 percent of the number of apartments. Apartments adjacent to elevator or ventilation shafts (or other spaces that run vertically through the property) might have a higher risk for elevated radon levels and should therefore be selected for measurements.

7. National grants and tax deductions for radon remediation in dwellings

	Denmark	**Finland**	**Norway**	**Sweden**
Grants	No	No	No	No
Tax Deduction	No	Yes	No	Yes

Denmark: The Danish Tax Agency used to provide options for tax-deductions in this regard. The deduction applied to costs related to work (materials not included) on a selection of craftsman services with energy saving purposes, in the context of climate and other "green" measures, including radon mitigation in existing dwellings. This tax-deduction option was abolished in April 2022.

Finland: There are no grants for radon remediations, but a deduction of tax of earned income can be applied as part of a general system for tax deduction for craftsman services.

Norway: There is no scheme for tax deduction on radon remediation or craftsman services in general. In the period 1999-2003 there was a subsidy scheme for grants, but as of today there is none.

Sweden: A radon remediation grant is not available since 2021 and it was not presented in the national budget for 2024. In Sweden a tax deduction, which is part of a general system for tax deduction for craftsman services, is available for work related to radon mitigation and comprise 30% of the cost, however, a maximum of 50 000 Swedish crowns per person.

8. Reference levels and limit values for workplaces

	Denmark	Finland	Norway	Sweden
Reference levels and limit values	100 Bq/m^3	300 Bq/m^3 or 0.5 MBqh/m^3/y	Action level: 100 Bq/m^3 Maximum level: 200 Bq/m^3 Underground: Step-by-step approach (see text below)	200 Bq/m^3 Limit values per year: -Above ground: 0.36 MBqh/m^3 -Underground, such as in completed and furnished rock rooms and rock facilities, basements: 0.72 MBqh/m^3 -Underground, such as mining, construction work, rock rooms, tunnels: 2.1 MBqh/m^3

Denmark: Optimization must be carried out in workplaces if the annual average radon activity concentration exceeds the reference level on 100 Bq/m^3 and a radiological surveillance program, accepted by The Danish Health Authority, must be implemented. In addition, provisions regarding monitored and controlled areas apply. There are requirements for license or notification, subject to exposure levels corresponding to 6 and 1 mSv per year respectively. Workplaces subject to requirement for licensing (>6mSv/year) are further subject to requirements for safety assessments.

For evaluation of the exposure resulting from radon, measurements must account for radon activity concentrations during working hours. The general provisions regarding measurement procedures described in chapter 6 apply. There are no specific requirements for how to undertake measurements such as to account for radon concentrations during working hours only. However, guidelines from the Danish Building Research Institute suggest the use of electronic measurement devices in conjunction with track-etch dosimeters. Here, the electronic measurement device is used to track short term fluctuations and the validity of the electronic measurements is tested by comparison of the recorded average activity concentration to the result from the track-etch dosimeter readout.

Finland: For workplaces, the reference level is 300 Bq/m^3 if working time in a workspace is ≥ 600 hours per year per person. If working time in a room/space is < 600 hours per year per person, radon activity concentration may be greater than 300 Bq/m^3, but radon exposure must then be determined. The reference level for radon exposure is 500 000 Bq h/m^3 per year.

If the workplace has intermittent ventilation that is set to low power outside working hours, the initial integrated measurement can be supplemented by an additional continuous measurement (1 week duration). The radon activity concentration is calculated as annual average of radon activity concentration during working hours (C_a):

$$C_a = \frac{c_1}{c_2} \cdot C_{LT} \cdot 0.9,$$

where c_1 is average radon activity concentration during working hours based on a continuous radon measurement over one week, c_2 is average radon activity concentration of the entire continuous radon measurement and C_{LT} is the result of the long term (>2 months) radon measurement.

If the radon activity concentration or radon exposure can't be reduced below the reference level, the employer must apply for a safety license, similar to that for planned exposure situations. In this context, the applicant must include a description of the management system and a safety assessment. The employer must appoint a radiation protection officer and utilize the services of a radiation protection expert. Dose limit of 20 mSv is applied in this planned exposure situation.

Norway: Radon in the workplace is regulated in general terms in The Working Environment Act, managed by the Labour Inspection Authority. The employer shall ensure a fully satisfactory working environment. Generally, there are no legally binding limits, but the DSA general recommendations (100 Bq/m^3 and 200 Bq/m^3) should be taken into account when considering radon exposure in the working environment. This advice is given in guidelines from the Labour Inspection Authority.

An exception is radon levels in schools and kindergartens, which are regulated with legally binding indoor limits (100 Bq/m^3 and 200 Bq/m^3 as action and maximum level, respectively) as a part of the radiation protection regulations.

There is no specific measurement procedure for radon in workplaces, but it is recommended to use the measurement procedure made for schools and kindergartens when appropriate. That is, when the mechanical ventilation is turned off at night, the radon activity concentrations are calculated the same way as in Finland, but without the use of a seasonal correction factor.

For underground workplaces, the guidance from the Labour Inspection Authority proposes a graded approach system: Initially, also underground workplaces should meet the general DSA recommendations. If the radon level is above the general recommendation, 100 Bq/m^3 and 200 Bq/m^3, despite measures to lower the radon activity concentration, the actual annual radon exposure to the workers should be calculated. If this is above 0.36 MBqh/m^3, the employer should inform the employees, the workplace should be measured more regularly to ensure updated exposure calculations and there should be in place routines and measures that ensure the lowest possible exposure. For purpose-built workplaces, such as hydro-electric power stations and office like workplaces, the guidance sets an upper annual exposure limit at 0.72 MBqh/m^3. A radon exposure of 0.72 MBqh/m^3 corresponds approximately to an effective dose of 6 mSv, using the dose conversion factor given in ICRP137. If this limit can be exceeded for other underground workers, like miners and tunnel engineering workers, their individual exposure should be monitored or measured and calculated yearly, preferably with individual radon exposure measurements. The annual radon exposure of 2.1 MBqh/m^3 is the upper recommended limit and should never be exceeded.

Sweden:

The national reference level for radon activity concentration as established in Sweden is 200 Bq/m^3 of indoor air in dwellings, premises to which the public has access and in working places, expressed as an annual average activity concentration in accordance with 3 chapter 6 section in the Radiation Protection Ordinance (2018:506).

According to 4 section in the SSM's regulation on radon in workplaces SSMFS 2018:10, workplaces must notify SSM if the radon activity concentration (annual average) is above the national reference level of 200 Bq/m^3, if undertaken measures cannot reduce the radon activity concentration below the reference level.

With the help of results from long-term measurement, the annual average value of radon activity concentration during working hours can be estimated to be compared to the reference level. Sometimes, however, an estimated annual average value based only on a long-term measurement can give an overestimation of the radon level during working hours at the workplace. It happens when the ventilation is set to lower ventilation rate or completely switched off outside working hours. Therefore, if the long-term measurement result is higher than the reference level 200 Bq/m^3, an additional, so called, a follow-up measurement may need to be done which, together with the long-term measurement, is used to estimate the annual average value during working hours.

It is sufficient to carry out the follow-up measurement in points where the long-term measurement shows that the radon level has exceeded the reference level or alternatively in a selection of such measurement points. The follow-up measurement should be performed during or in close connection with long-term measurement. Moreover, the follow-up measurement must be carried out continuously with time-resolved measuring equipment, which can effectively distinguish measurement values during working hours and non-working hours. The follow-up measurement must be done for at least 7 days, of which 5 days should be during working days.

Finally, the radon activity concentration is calculated as annual average of radon activity concentration during working hours (C_a) using the following formula:

$$C_a = \frac{c_1}{c_2} \cdot C_{LT},$$

where c_1 is average radon activity concentration during working hours based on the follow-up measurement, c_2 is average radon activity concentration of the whole follow-up measurement and C_{LT} is the result of the long-term (at least 2 months) radon activity concentration measurement.

According to 5 section in the SSM's regulation SSMFS 2018:10, employers must notify SSM if employees are exposed to, or risking to be exposed to, an annual radon exposure level that exceeds 0.72 MBq·h/m^3. So if the annual average radon activity concentration is above the reference level for work places, the annual radiation exposures to radon must be estimated for each employee who works in this environment. Additional notification to SSM is mandatory if a worker may have received an annual radon exposure which exceeds 2.1 MBq·h/m^3 in accordance with 16 section in the SSM's regulation SSMFS 2018:10.

Radon levels at workplaces are regulated not only by the national reference level, but also by maximum permitted levels of annual radon exposure at work. Radon exposure at workplaces is in Sweden regulated by the SSM (SSMFS 2018:10) and the Swedish Work Environment Authority (AFS 2018:1).

If the radon activity concentration is above the reference level for workplaces, the annual radon exposure must be estimated for each employee. These values must then be compared to national maximum permitted levels, so called hygienic limit values, which are established by the Swedish Work Environment Authority, see regulation AFS 2018:1. In accordance with items 41 and 42 in the regulation AFS 2018:1, there are three hygienic limit values depending on the type of working place:

- For underground work, the annual radon exposure must not exceed 2.1 MBq·h/m^3. Underground work refers to mining work, underground construction work and similar, as well as temporary work in underground premises, rock rooms, tunnels and similar.
- For other types of underground work, such as work in completed and furnished rock rooms and rock facilities, basements and similar, the annual radon exposure must not exceed 0.72 MBq·h/m^3.

- For work other than underground work, the annual radon exposure must not exceed 0.36 $MBq \cdot h/m^3$.

In case the estimated annual radon exposure exceeds the related maximum permitted level, appropriate measures must be taken to reduce the exposure below the corresponding limit according to the regulation AFS 2018:1. Further, optimization related to the radon exposure has to be applied in accordance with 3 chapter 5 section in the Swedish Radiation Protection Act (2018:396).

9. National quality recommendations, target values and requirements for drinking water

Denmark	
Private wells supplying one home	No requirements
Private wells supplying more than one home and waterworks	Quality requirements: 100 Bq/L

Finland	
Private wells	Quality recommendation: 1000 Bq/L
Small waterworks[1)]	Quality recommendation: 300 Bq/L
Larger waterworks	Quality target value: 300 Bq/L Quality requirements: 1000 Bq/L

1) Less than 50 users or less than 10 m^3 per day.

Norway	
Private wells supplying one home	No requirements > 500 Bq/L, mitigation recommended by DSA
Private wells supplying more than one home and waterworks	Quality requirements: 100 Bq/L

Sweden	
Private wells and small waterworks[1)]	Quality recommendation: < 1000 Bq/L
Larger waterworks	Quality requirement: ≤ 100 Bq/L

1) Less than 50 users or less than 10 m^3 per day

Denmark: The Reference level is only valid when the private well is used by more than one house or for commercial or public activities. Investigations of radon in drinking water in Denmark showed that the drinking water in Denmark has a low content of radon, and in compliance with Council Directive 2013/51/Euratom it was concluded that continuous control measurements of the drinking water is not applied. The reference level above refers to the level above which, continuous control measurements are to be applied.

Finland: Two ordinances are applied in regulatory of drinking water. The competent authority is the local health protection authority. Ordinance 401/2001 regulates radioactivity in private wells and small waterworks (less than 50 users or less than 10 m^3 per day). The recommended maximum radon activity concentration is 300 Bq/L for waterworks and 1000 Bq/L for private wells. If deemed necessary, the local health protection authority may impose additional measurements of radioactivity. Ordinance 1352/2015 regulates larger waterworks, water distributed in bottles or tanks, and food processing facilities using private water source. The recommended maximum radon activity concentration (quality target value) is 300 Bq/L and the maximum activity concentration (quality requirement) is 1000 Bq/L. The maximum value (quality requirement) for the indicative dose is 0.10 mSv per year. If the radon activity concentration is between 300 and 1000 Bq/L, corrective actions are considered based on risk assessment.

Norway: The maximum permitted level of radon in drinking water from waterworks is 100 Bq/L. A well supplying two or more homes is defined as a waterworks. Norwegian Food Safety Authority is the regulatory authority with regard to radioactivity in water. Private wells supplying only one home are not subject to the regulations. For these water supplies, DSA recommends remediation to be carried out if the water has a radon activity concentration of more than 500 Bq/L.

Sweden: The Swedish Food Agency is the authority responsible for drinking water quality in Sweden, and corresponding requirements are given in the regulations LIVSFS 2022:12 on drinking water. The regulations require that radon activity concentration in drinking water does not exceed 100 Bq/L. The radon activity concentration of the drinking water needs to be investigated if it is groundwater, or if it is groundwater-affected surface water. The regulations apply to operators who on average produce or supply at least 10 m^3 of drinking water per day, or supply at least 50 persons with drinking water. Drinking water supplied as part of a commercial or public activity however, is always subject to the regulations. For small operators and private wells, the quality recommendation from the Swedish Food Agency is that the radon activity concentration should be <1000 Bq/L (Livsmedelsverket.se).

10. National gamma radiation reference levels

	Denmark	Finland	Norway	Sweden
Gamma radiation in new buildings	1 mSv/y	1 mSv/y	-	0.3 µSv/h [1)]
Gamma radiation from building material	1 mSv/y	1 mSv/y	-	1 mSv/y[2)]

[1)] Expressed as dose equivalent rate.
[2)] Expressed as an annual effective dose.

Denmark: Reference levels for exposure to external gamma radiation from building materials are set in Executive Order 669 §102 stating that at workplaces where indoor exposure to external gamma radiation from building materials exceeds the reference level, optimising measures must be taken to reduce the exposure as much as is reasonably achievable.

Executive Order 669 §103 further states that prior to marketing of building materials emitting gamma radiation which may cause doses exceeding the reference level, the company marketing the material must determine the activity concentration of the radionuclides concerned and make the measurement results and corresponding activity concentration index values concerning Ra-226, Th-232 and K-40 available to the Danish Health Authority.

Finland: Radiation act (859/2018, 153 §) stipulates that the party transporting or importing construction products into Finland, or producing construction products in Finland, is responsible for investigating the radiation exposure caused by the product if it may exceed the reference level. If the reference level may be exceeded, the responsible party must ensure that the product is accompanied by instructions and safety information according to Regulation (EU) No 305/2011. The construction products that must be investigated are listed in ordinance 1034/2018, 53 §. The reference level for exposure from construction products is given in ordinance 1044/2018, 24 §, and is 1 mSv per year in buildings and 0.1 mSv per year in other built environments. The reference level is defined as the addition of the external dose to the natural background radiation.

Regulation STUK S/6/2022 establishes screening values to ensure compliance with the reference level. Screening involves gamma spectroscopic measurement of Ra-226, Th-232 and K-40, as well as the use of index value calculations. Further assessments of radiation doses are conducted by numerical dosimetry before the construction product is used. STUK serves as the competent authority for regulatory control. STUK forwards all obligating regulatory control decisions to Finnish Safety and Chemicals Agency (Tukes), which is responsible for overseeing compliance with Regulation (EU) No 305/2011.

Norway: There is no specific regulatory reference or limit value for radioactivity in building materials in Norway. This is only regulated in more general terms. References are made to the publication "Naturally Occurring Radioactivity in the Nordic Countries – Recommendations", given by the Nordic Radiation Protection Authorities, when appropriate.

Sweden: In accordance with 3 chapter section 7 in the Radiation Protection Ordinance 2018:506, the reference level for external exposure to gamma radiation from building materials is 1 mSv, expressed as annual effective dose, to people residing in a building.

In accordance with section 6:12 in the building code BFS 2011:6 issued by the Swedish National Board of Housing, gamma radiation shall not exceed 0.3 µSv/h in rooms where people reside more than temporarily. The building regulations are currently under review and the regulation for gamma radiation for building materials will (probably) be removed, with the motivation that it suffices with the reference value for gamma radiation for building materials in the Radiation Protection Ordinance.

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Appendix 1: National action plans

Denmark
Radonhandlingsplan
https://www.sbst.dk/Media/638249136322110864/Radonhandlingsplan.pdf (in Danish)

Short info: Lead agency is Danish Transport, Construction and Housing Agency, with contributions from other stakeholders and regulatory bodies, such as The Danish Health Authority and The Danish Building Research Institute.

Finland
National action plan to prevent radon risks | Säteilyturvakeskus STUK National Radon Action Plan to Prevent Radon Risks (julkaisut.valtioneuvosto.fi)

Authority: Ministry of Social Affairs and Health
Short info: STUK (coordinator), in cooperation with Ministry of Social Affairs and Health, Ministry of Environment, Health Protection, Environmental Health (governmental & regional), Occupational Safety and Health (governmental & regional), National Supervisory Authority for Welfare and Health (Valvira), Association of Finnish Local and Regional Authorities

Norway
Strategy for the reduction of radon exposure in Norway, 2009
https://www.dsa.no/publication/strategy-for-the-reduction-of-radon-exposure-in-norway.pdf (in English)
https://www.regjeringen.no/globalassets/upload/hod/dokumenter-fha/strategi-for-a-redusere-radoneksponeringen-i-norge.pdf (in Norwegian)

Short info: DSA (coordinator), The Directorate of Health, The Institute of Public Health, The Norwegian Labour Inspection Authority, The Norwegian State Housing Bank, National Institute of Occupational Health, Norwegian Building Authority, Dep. for Planning, Ministry of Local Government and Modernization, Geological Survey of Norway, and the municipalities of Oslo and Hamar.

Sweden
Nationell handlingsplan för radon https://www.stralsakerhetsmyndigheten.se/globalassets/radon/nationell-handlingsplan-for-radon.pdf (in Swedish)

Short info: Strålsäkerhetsmyndigheten (SSM) (coordinator), Folkhälsomyndigheten, Boverket, Sveriges Geologiska Undersökning (SGU), Livsmedelverket, Arbetsmiljöverket, SWEDAC

Appendix 2: Measuring procedure for radon in dwellings

Denmark
Måling af radon i bygninger
https://www.anvisninger.dk/ (In Danish, for sale)
Publisher: The Danish Health Authority and The Danish Building Research Institute (SBI) in cooperation with The Danish Health Authority, The Danish Transport, Construction and Housing Agency and others.
Year: 2018
Short info: Guideline on measuring radon in all types of buildings. Measuring Protocol referred to by the Danish Health Authority.

Finland

Measuring radon | Säteilyturvakeskus STUK Publisher: STUK
Year: 2023
Short info: Protocol for radon measurements
Taloyhtiöiden radonopas / Radon i husbolag
Year: 2024
Short info: Guideline on management of radon measurements and mitigation in housing cooperatives.

Norway
Måleprosedyre for radon i boliger
(in Norwegian)
Authority: DSA
Year: 2013
Short info: Protocol for radon measurements

Sweden
Mätning av radon i bostäder - metodbeskrivning
matning-av-radon-i-bostader--metodbeskrivning (stralsakerhetsmyndigheten.se) (in Swedish)
Publisher: SSM
Year: 2013
Short info: National protocol for radon measurements in dwellings. The purpose of the SSM's protocol is to ensure accurate and consistent radon measurements with high quality in dwellings. The protocol gives the procedure for measuring the annual average radon activity concentration.

Appendix 3: Other relevant protocols and guidance material for the management of radon

Denmark

SBi Anvisning 233 (2015): Radonsikring af nye bygninger (in Danish)
https://www.anvisninger.dk/
Short info: Radon prevention in new buildings. Subscription required.

SBi Anvisning 247 (2016): Radonsikring af eksisterende bygninger (in Danish)
https://www.anvisninger.dk/
Short info: Radon remediation of existing buildings. Subscription required.

Finland

About Radon | Säteilyturvakeskus STUK Radon at workplace | Säteilyturvakeskus STUK

The radioactivity of building materials and ash | Säteilyturvakeskus STUK
Monitoring of radioactivity in household water | Säteilyturvakeskus STUK

Norway

Protocol for radon measurements in schools and kindergartens, 2015
https://www.dsa.no/publication/protocol-for-radon-measurements-in-schools-and-kindergartens.pdf (In English)
https://www.dsa.no/publikasjon/maaleprosedyre-for-radon-i-skoler-og-barnehager-2015.pdf (in Norwegian)
Authority: DSA

Radon fra tilkjørte masser under bygg – anbefalt grenseverdi
https://www.dsa.no/publikasjon/straaleverninfo-6-2015-radon-fra-tilkjoerte-masser-under-bygg-anbefalt-grenseverdi.pdf
(in Norwegian)
Short info: Radon from gravel etc. under buildings – recommended reference level for Ra-226 and uranium.

Anbefalt prosedyre for prøvetakning og analyse av pukk med hensyn på radonavgivelse
https://www.ngu.no/sites/default/files/radonfrapukk.pdf (in Norwegian)
Authority: NGU og DSA
Short info: Recommended procedure for sampling and analysis of gravel for the measurement of uranium concentration.

Veileder i tilsyn med radon i skoler, barnehager og utleieboliger
https://dsa.no/publikasjoner/Veileder_tilsyn skoler,barnehager og utleieboliger.pdf (in Norwegian)
Authority: Directorate of Public Health and DSA
Short info: DSA and the Directorate of Health, in cooperation, have established a system for radon inspections in schools, kindergartens and rental accommodations, where the municipalities will be primarily responsible for performing the inspections, according to their own regulations.

Guidance material for radon in workplaces
https://www.arbeidstilsynet.no/tema/straling/radon/ (in Norwegian)
Authority: Norwegian Labour Inspection Authority
Short info: Guidance material for workplaces (offices and underground) at the Norwegian Labor Inspection Authorities website.

Sweden

Measurement protocol for workplaces
Metodbeskrivning för radonmätning på arbetsplatser (stralsakerhetsmyndigheten.se) (in Swedish)
Publisher: SSM
Year: 2021
Short info: This measurement protocol applies to workplaces indoors. For completed and furnished rock rooms, rock facilities, basements and similar environments, it can also be used, but a special assessment may then need to be made to determine applicability. However, the method description does not apply to mines and underground facilities under construction.

Guidance for radon supervision of housing and premises with public access
Handbok: Radon – Bostäder och lokaler dit allmänheten har tillträde - Strålsäkerhetsmyndigheten (stralsakerhetsmyndigheten.se) (in Swedish)
Publisher: SSM
Year: 2020.
Short info: This guidance intends to assist the local environmental offices in their supervision of radon in dwellings and premises where the public have access. In addition it can also be used by property owners and others who are subject to inspection by the local environmental offices.

Guidance for radon activity concentration measurements in schools and kindergartens
Vägledning för mätning av radonhalten i skolor och förskolor (stralsakerhetsmyndigheten.se) (in Swedish)
Publisher: SSM
Year: 2022
Short info: This guidance, which was issued 2006 and revised in 2022, provides a supplement to the measurement protocol for workplaces and it includes recommendations on how to measure radon in schools and kindergartens.

Appendix 4: Relevant legislation

Denmark

Act No. 23 of 15/01/2018 - Act on Ionising Radiation and Radiation Protection (The radiation Protection Act)
Executive Order No. 669 of 01/07/2019 - Executive Order on Ionising Radiation and Radiation Protection
Consolidation Act No. 1178 of 23/09/2016 - Consolidation Act on Construction (The Construction Act)
Executive Order No. 1399 of 12/12/2019 - Executive order on Building Regulations (BR18)

Finland

Radiation Act (859/2018)
GDIR, 2018. Government Decree on Ionising Radiation (1034/2018)
The National Building Code of Finland: https://www.ym.fi/en-US/Land_use_and_building/Legislation_and_instructions/The_National_Building_Code_of_Finland

Norway

Act on Radiation Protection and Use of Radiation (No. 36 of 12 May 2000)
Regulations on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (PDF-file)
Byggteknisk forskrift (TEK17) med veiledning, https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17
Regulations on technical requirements for construction works (TEK17), https://www.dibk.no/globalassets/byggeregler/regulation-on-technical-requirements-for-construction-works--technical-regulations.pdf

Sweden

SFS 2018:396. Swedish Radiation Protection Act, 2018.
SFS 2018:506. Swedish Radiation Protection Ordinance, 2018.
SSMFS 2018:10."Strålsäkerhetsmyndighetens föreskrifter om radon på arbetsplatser", regulation concerning radon at workplaces from the Swedish Radiation Safety Authority, 2018.
AFS 2018:1. "Hygieniska gränsvärden. Arbetsmiljöverkets föreskrifter och allmänna råd om hygieniska gränsvärden", regulation concerning limit values at workplaces from the Swedish Work Environment Authority, 2018.
LIVSFS 2022:12. Livsmedelsverkets föreskrifter om dricksvatten, regulation on drinking water from the Swedish Food Agency, 2022.

BEREDSKABS STYRELSEN

DANISH HEALTH AUTHORITY
Radiation Protection

GEISLAVARNIR RÍKISINS
ICELANDIC RADIATION SAFETY AUTHORITY

Strål säkerhets myndigheten
Swedish Radiation Safety Authority

stuk

DSA Norwegian Radiation and Nuclear Safety Authority