NORWEGIAN MINISTRIES

Strategy

Strategy for the reduction of radon exposure in Norway

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1. Introduction

1.1 RADON - A NATIONAL CHALLENGE

Elevated indoor radon concentrations are a more extensive problem in Norway than in many other countries. It has been estimated that indoor radon causes approximately 300 deaths from lung cancer each year in Norway. On average, avoiding lung cancer increases life expectancy by 14 to 18 years.

Radon is a radioactive noble gas formed continually as a decay product from uranium. Uranium is a natural constituent existing in varying concentrations in bedrock, minerals and soils. For this reason, both the soil air and groundwater contain radon. Radon in buildings normally originates from the soil air in the underlying ground. Indoor air pressure is often low, so that radon-containing air from the surrounding ground gets sucked in through cracks in the building foundations. Elevated indoor radon concentrations can be due to household water drawn from groundwater wells, and radon gas can also be emitted from building materials such as certain types of stone or concrete containing high levels of natural radioactivity.

Norway, Sweden and Finland are among the countries in the world with the highest average indoor radon concentrations. Geological conditions and the cool climate pose a big challenge, but the radon problem can be solved in a cost-effective way.

Radon is the most common cause of lung cancer after active smoking. At a radon concentration of 100 Bq/m^3, which is not far from the estimated average for Norwegian housing, the risks of dying of radon-induced lung cancer before the age of 75 are 0.1 % for non-smokers and 2 % for smokers, respectively. Many buildings in Norway have radon levels that exceed this.

The most important health impact of radon exposure is the increased risk of lung cancer. This increase in risk is assumed to be linear in relation to radon concentration (i.e., the risk is 10 times higher at 1000 Bq/m^3 compared to 100 Bq/m^3). The risk also increases linearly with exposure time, i.e. there is a tenfold greater risk of contracting lung cancer caused by radon if you have lived in a house for 30 years, compared to if you lived in the same house (with the same radon levels) for 3 years. The above relationships are especially important when considering which mitigation measures should be implemented. All reduction of radon concentration and exposure time will have a favourable impact on health. Taking the population as a whole, the health benefit will be appreciable, even if the exposure reduction that is achieved from the measures is modest - so long as the reduction applies to a large number of buildings.

The risk of radon induced lung cancer increases with exposure and is proportional to the indoor radon concentration and the exposure time. Moreover, there is no lowest threshold radon concentration where no risk occurs. The risk is greatest for smokers and ex-smokers, though never-smokers can also develop lung cancer as a result of radon exposure. In recent years, three important large-scale international pooled analyses of available reliable data have confirmed earlier risk estimates.

1.2 STRATEGIC GOALS

The Norwegian government will:

- *Work towards reducing radon levels in all types of building and premises to below the stated limits*
- *Contribute to reducing radon exposure in Norway as low as reasonably achievable.*

As low as reasonably achievable implies that radon exposure should be reduced as much as reasonably possible, not only to a level just below the stated maximum limit.

The choice of strategic goals is based on the knowledge that the risk from radon is proportional to exposure with no lower safe threshold value, such that all reduction of radon exposure will yield a health benefit. Radon can be present in all types of building and premises, and efficient prevention of radon risk therefore implies that radon levels must be reduced generally across society. The strategic

goal of achieving as low radon levels as reasonably achievable is supplemented with legally binding limits where appropriate. This will ensure that the authorities have a basis for effective enforcement and compliance.

The maximum limit for kindergartens, schools, new dwellings and rented accommodation will be set at 200 Bq/m^3, with 100 Bq/m^3 as the action level. This is in line with the current recommendations from the World Health Organisation (WHO) and is supported by the Norwegian Radiation Protection Authority. The Norwegian Labour Inspection Authority determines and monitors the action and maximum limits for radon exposure in workplaces, in order to ensure a fully adequate working environment.

Sub-strategies are proposed for work on:
- Radon in land planning
- Radon and the construction of new buildings
- Radon in existing dwellings
- Norwegian communities exposed to especially serious radon problems
- Radon in buildings and premises to which the general public are admitted
- Radon in the workplace

1.3 DEVELOPMENT OF THE STRATEGY

The Norwegian Ministry of Health and Care Services has led a multi-sector working group that started in the autumn of 2007 on a report covering the challenges faced and available mitigation measures regarding radon. The working group consisted of delegates from the Ministry of the Environment, the Norwegian Labour Inspection Authority, the National Office of Building Technology and Administration, the State Housing Bank, the National Institute for Public Health, the Norwegian Directorate of Health and The City of Oslo. The Norwegian Radiation Protection Authority acted as the secretariat for the working group.

The group's mandate was to suggest specific initiatives that can contribute to reducing exposure to radon in dwellings and workplaces. The group discussed methods and strategies and proposed specific measures that can contribute to reducing the general public's exposure to radon. The work included measures for limiting radon levels in newly constructed buildings and to reduce radon levels in existing buildings. The mandate also included the consideration of financial support schemes or other measures that could stimulate the implementation of radon-mitigating measures. The working group ended in the spring of 2009, when it formally submitted its report to the Ministry of Health and Social Care Services.

A reference group was also established with participants from trade unions and non-governmental organisations who have knowledge and interests in the radon field. The reference group commented on the working group's proposed measures during the study process, and has commented on the working group's final report.

The working group's report will be used as the basis when following up this strategy.

As radon also is an issue on Spitsbergen, the measures proposed in the strategy must also be considered in relation to Spitsbergen.

1.4 FOLLOW-UP AND DURATION

The national strategy shall be implemented in the five-year period 2009-2014 based on annual national budgets, grant schemes and relevant government documents. The strategy is a tool for management and coordination of radon-prevention work in many sectors. The Norwegian Radiation Protection Authority shall create a coordination group that will follow up the strategy. The coordination group shall consist of participants from sectors that have policy instruments relevant to radon, and be able to produce and suggest actions relevant to radon prevention measures during the strategy period. The Norwegian Radiation Protection Authority will be able to report achievement of targets to the Ministry of Health and Care Services through the ordinary steering dialogue it has with the ministry.

The working group points out in its report that radon is an important factor in connection with house sales in the housing market. For this reason, the working group sent over a proposal for how radon information can become part of survey reports for homebuyers to the Survey Act Committee in May 2008.

The building section of the new Planning and Building Act is intended to enter into force during 2010. As part of this Act, new technical regulations concerning the requirements for construction techniques will be drawn up. This work is underway under the leadership of the Ministry of Local Government and Regional Development (KRD). The working group has also drawn up and submitted a proposal to KRD/the National Office of Building Technology and Administration, containing draft requirements for radon-preventive measures in new buildings, as well as suggested mandatory limits.

Guidelines for the planning section of the Planning and Building Act are also being prepared. The working group was invited by the Ministry of Environment to provide radon proposals and information for land planning for this process, and the work on this will be followed up by, amongst others, the Norwegian Radiation Protection Authority.

1.5 FINANCIAL AND ADMINISTRATIVE CONSEQUENCES

There are a number of publications that summarise research and calculations for the creation of cost-effective radon reduction strategies using anti-radon measures in existing buildings (see e.g. the WHO Handbook on Indoor Radon published in 2009, a report from the International Radon Project 2005 - 2008 under the aegis of the WHO). The scientific publications show that radon reduction measures are cost-effective. In different countries, with different radon levels and differing cost levels for anti-radon measures, the cost-effectiveness for a given measure level will vary. A cost-efficiency analysis has previously been published regarding Norwegian radon conditions (Stigum and Strand, 2003), which showed that radon reduction measures in existing buildings with levels above 200 Bq/m^3 are cost-effective.

A cost-efficiency analysis has also been carried out on behalf of the Norwegian Radiation Protection Authority for an action limit of 100 Bq/m^3. This study calculated a cost per lung cancer occurrence saved by reducing the action limit to 100 Bq/m^3 of NOK 3 million, which is equivalent to between NOK 170 000 and 210 000 per year of life saved. The results of this analysis harmonise well with a similar analysis carried out in connection with the WHO's International Radon Project. The analysis is based on current cost levels for radon reduction measures, which are regarded as being unnecessarily high. The report points out the potential cost reductions that can be achieved by making the radon reduction measures themselves more cost-efficient.

Setting maximum radon limits and action levels that are legally binding for kindergartens, schools and rented accommodation will lead to costs incurred for the municipal and private owners of such buildings. Survey costs will include all buildings covered by the regulations, while costs of mitigation measures will include only some buildings and to varying extents, depending on type of building, radon levels and how radon enters the building. This involves a relatively low cost for most buildings, but a relatively high cost for a few buildings, estimated at between 3 and 9 % dependent on building type.

Cost estimates carried out by the Norwegian Radiation Protection Authority for survey and mitigation action initiatives show an average total cost per kindergarten and per school of NOK 3000 and 7000, respectively. The total survey and action costs for all kindergartens, schools and rented accommodation in Norway have been calculated as approximately NOK 20 million for kindergartens, approximately NOK 20 million for primary and secondary schools and approximately NOK 10 million for further education colleges and centres of higher learning. Around half of all kindergartens are run by local authorities.

The estimated average cost per rented accommodation is approximately NOK 1700, but this is also expected to vary a lot, especially between buildings with radon values above or below 200 Bq/m^3. The total survey and mitigation action costs for rented accommodation are estimated to be approximately NOK 900 million, of which about NOK 100 million is made up of rented accommodation owned by local authorities in Norway.

The costs due to radon-preventive measures being required when constructing new buildings is calculated as approximately NOK 17 000 per 100 m^2 of floor space if a radon membrane is used.

The other measures in the strategy can be accomplished within existing budgets, and do not require any administrative amendments. If proposals are put forward during the strategy period that cannot be covered by reallocations within existing budgetary frameworks, these will be considered in connection with the preparation of annual national budgets.

2. Sub-strategies

2.1 RADON IN LAND PLANNING

Target:
Radon must be emphasised in a systematic and sufficient way in all land planning.

The new planning part of the Planning and Building Act entered into force on 1 July 2009. Risk areas, or areas with potential risk, will be given special consideration. The potential for any building to have high indoor radon concentrations is highly variable, due to the large variation in geological conditions. Little account of radon risk is currently taken in land planning. A principal challenge for the work of local authorities in land planning in relation to radon will be to classify the land in relation to the radon hazard.

Measures:
- Contribute to the development of knowledge regarding the relationship between radon hazard and geological conditions, as well as which requirements must be set for radon protection of buildings in relation to different degrees of radon hazard.
- Consider developing a map-based tool for use in assessing radon hazard when planning land use at local and regional levels.
- Consider establishing routines and systems that ensure that data concerning the building ground and geology, radon in household water supplies from drilled wells, building construction and radon in the indoor air are collected, both from the public and private sectors. These data should be made available for relevant local, regional and central authorities for administrative/management purposes.
- Work at identifying the occurrence of local areas with permeable surficial sediments/deposits and radium-rich bedrock.
- Draw up guidelines for local authorities concerning radon in planning applications.
- Contribute such that County Governors' also consider radon in their land planning activities, e.g. when considering objections.
- Contribute such that regional authorities also consider radon as one of their consultancy responsibilities with regard to local authority planning.

2.2 RADON AND THE CONSTRUCTION OF NEW BUILDINGS

Target:
New buildings that are being constructed in Norway must have indoor radon concentrations that are as low as reasonably achievable and always less than 200 Bq/m^3.

This target can be achieved by setting specific requirements for anti-radon measures in all new buildings in the technical regulations pursuant to the Planning and Building Act. Specific requirements may include the use of radon barriers (e.g. a membrane), or the required ventilation of the ground below the building. It is difficult to estimate values for indoor radon concentrations in structures before they have been completed and taken into use. However, by setting requirements for preparing the buildings foundations such that it is possible to use active ventilation of the ground, it will be easier to carry out subsequent initiatives with ventilation/pressure modification to reduce the radon concentration to an acceptable level if the indoor radon levels are deemed too high in the finished building. An upper limit should be set to ensure that individuals are not exposed to unacceptable radon levels over time. Radon surveys should be carried out in all new buildings when they are taken into use.

Measures:
- Describe standardised methods for radon-preventive measures to be used when constructing new buildings and premises.
- Introduce minimum requirements for radon-preventive measures when constructing new buildings.
- Introduce legally binding limits for indoor radon concentrations in new buildings.

- Issue user-oriented guidelines that describe the regulatory framework and clarify the areas of responsibility for radon when constructing new buildings.
- Develop guidelines for use by local authorities in their supervision of the construction of new buildings.
- Develop information material that will contribute to good control of engineering and construction with respect to radon and radon-prevention measures when constructing new buildings.
- Review the possibilities of setting requirements for radon surveys in completed new buildings.

2.3 RADON IN EXISTING DWELLINGS

Target:
The proportion of dwellings with indoor radon concentrations exceeding 200 Bq/m³ must be considerably reduced by 2020. The average indoor radon concentration must be reduced considerably by 2020, and a large proportion of dwellings must have achieved as low radon levels as reasonably achievable.

The threshold for intervening and regulating conditions in private dwellings is, and should be, high. Different measures other than legal initiatives should therefore be primarily employed to motivate and encourage homeowners to carry out radon surveys and technical preventive measures in their own homes. Information and measures to raise awareness about the radon problem should be most important. One condition for achieving the targets is that the radon-reduction building engineering methods are cost-efficient, safe and reliable. The development of better expertise and increased capacity for carrying out radon-reduction measures within the building industry will also be important.

Measures:
- Carry out systematic studies of radon in dwellings situated in all municipalities.
- Consider implementing problem-oriented surveys of radon in household water supplies.
- Consider requirements for information about radon in building surveys for homebuyers in connection with selling/buying housing.
- Clarify the Radiation Protection Act with regard to radon and who it applies to.
- Inform the population about radon: health risks, surveys and the implementation of remedial measures in dwellings.
- Consider establishing a central radon register for use in research containing information about e.g., areas that are exposed to radon, building engineering radon mitigation measures etc.
- Consider the development of standardised radon-reducing measures for existing dwellings that ensure that the radon level is as low as reasonably achievable after implementation and that are robust and user-friendly.
- Contribute to strengthening radon expertise in educational institutions and among specialists, for example regarding building engineering methods and cost-efficiency.

2.4 NORWEGIAN COMMUNITIES EXPOSED TO ESPECIALLY SERIOUS RADON PROBLEMS

Target 1:
All Norwegian communities in "radon extreme areas" are mapped.

Target 2:
Acceptable health conditions for the inhabitants of such communities are ensured through the introduction of necessary measures.

Some specific areas exist in Norway where extreme radon problems occur in buildings. When dwellings are built in such areas, a large proportion of the buildings may have high radon values, including extreme values such as 2000 – 50 000 Bq/m³. Several such areas have been documented, but because the majority of Norwegian buildings have not yet been surveyed for radon, the possibility of finding other radon extreme areas during future surveys cannot be excluded. Such areas require special measures and follow-up.

Measures:
- Contribute such that the extent of dwellings and

local communities with extreme radon problems is ascertained and assess the need for measures targeted against these areas.
- Establish routines for the individual assessment and medical follow-up, if necessary, of persons who have been exposed to very high radon concentrations over long periods.
- Intensify information and survey campaigns when indications exist that a high radon hazard is present.
- Consider when Section 89 of the Planning and Building Act can be used as a basis for enforcing required actions by the owners of buildings and installations with high radon levels.

2.5 RADON IN BUILDINGS AND PREMISES TO WHICH THE GENERAL PUBLIC ARE ADMITTED

Target 1:
The proportion of buildings with indoor radon concentrations above the maximum limit (200 Bq/m^3) is to be reduced considerably by 2020.

Target 2:
The average indoor radon concentration is to be reduced considerably by 2020, and a large proportion of buildings have achieved as low radon levels as reasonably achievable.

Target 3:
All schools and kindergartens have radon concentrations below the stated maximum limit.

The working group has also focused attention on buildings and premises to which the general public is admitted, such as schools, kindergartens, children's care institutions, hospitals, jails, shopping malls, office buildings, hotels, restaurants, banks, commercial buildings, etc. Such buildings are often large and they contribute to the radon exposure of a large number of individuals. Those who are exposed to radon in such areas have no possibility of knowing that they have been exposed, or be in a position to reduce the exposure levels themselves. In schools and kindergartens especially, the children seldom have any choice with regard to their presence in the buildings. The combination of obligatory presence and young individuals indicates a need for especially stringent requirements.

Measures:
- Contribute to the development of knowledge regarding radon measurement techniques and anti-radon measures in large buildings.
- Consider the development of standardised radon measurement techniques and anti-radon measures in different types of building.
- Draw up legal requirements regarding achieving as low radon levels as reasonably achievable and limits for radon levels.
- Contribute with information and guidelines about radon to different groups of owners and users of buildings and premises to which the general public are admitted.
- Improve radon information to those responsible for schools and kindergartens.
- Consider when Section 89 of the Planning and Building Act can be used as a basis for enforcing required actions by the owners of buildings and installations with high radon levels.

2.6 RADON IN THE WORKPLACE

Target:
Norwegian workplaces shall have building and equipment conditions that ensure radon concentrations are suitable for a fully adequate working environment, based on consideration of employees' health, safety and the working environment.

Radon gas is the greatest source of exposure for ionising radiation amongst all Norwegian employees together. The initiatives that are outlined above will also have a positive impact by reducing employees' exposure to radiation.

Measures:
- Contribute to the development of knowledge about radon measurement techniques and anti-radon measures in large buildings.
- Consider the development of standardised radon measurement techniques and anti-radon measures in different types of building.
- Consider when Section 89 of the Planning and Building Act can be used as a basis for enforcing required actions by the owners of buildings and installations with high radon levels.
- Contribute with information and guidelines to employer and employee organisations, etc.

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