Regulation and National Radon Action Plan to optimise protection from radon exposure in workplaces and dwellings in Italy: Lessons from the past and challenges for the future

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Outline

• Past/present legislation ad NRAP (and some lesson learned)
• Forthcoming legislation and NRAP (and challenges)

Additional material can be provided (only conclusions are reported here):
• Affordable proxy of national surveys in dwellings
• Cost-effective analysis
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• Cost-effective analysis
• The present (since 2000) Italian regulation deals only with radon in workplaces, including schools:

  – Rn conc. meas. required in:
    • 1) all fully underground workplaces;
    • 2) all other workplaces (with priority to those in basements and at ground floor) only in Rn-prone areas declared by Regions.

  – Action level (AL) = 500 Bq/m$^3$.

  – Remedial action required if annual Rn conc. > AL and effective dose > 3 mSv (for schools if annual Rn conc. > AL only).

  – Notification only if Rn conc. > AL.
The Italian National Radon Action Plan

- Promoted by the Ministry of Health
- Prepared by a working group composed by experts from national institutes and universities
- Not supported by a national regulation (partly implemented through national and regional projects)
- Working groups and coordination (by ISS)
Surveys in dwellings

• After the first national survey (1987-1996), more detailed surveys have been conducted in several Regions, mainly aimed to identify Rn-prone (as requested by the Italian law for Rn in workplaces).

• Before the first Italian National Radon Action Plan (2002) these surveys were quite different protocols.
Surveys in dwellings
Surveys in workplaces (incl. schools)

- No national surveys have been conducted in schools.

- However, many Regions have conducted extensive surveys on all, or a large sample, of kindergartens and schools (usually primary schools and, less often, secondary schools).

- Some national surveys have been conducted in large samples of specific workplaces (e.g. banks, telephone company buildings).

- Only few regional surveys have been conducted in large samples of many types of workplaces.
### Radon surveys in dwellings, workplaces and schools

<table>
<thead>
<tr>
<th>Italian macro area</th>
<th>Dwellings</th>
<th></th>
<th>Workplaces</th>
<th></th>
<th>Schools</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National</td>
<td>Regional or sub-regional</td>
<td>National</td>
<td>Regional or sub-regional</td>
<td>Regional or sub-regional</td>
<td></td>
</tr>
<tr>
<td>North (East+West)</td>
<td>2 354</td>
<td>15 455</td>
<td>559</td>
<td>2 870</td>
<td>6 653</td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td>2 045</td>
<td>9 471</td>
<td>557</td>
<td>1 258</td>
<td>903</td>
<td></td>
</tr>
<tr>
<td>South and islands</td>
<td>3 669</td>
<td>2 407</td>
<td>1 199</td>
<td>129</td>
<td>1 349</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10 862</strong></td>
<td><strong>27 333</strong></td>
<td><strong>3 163</strong></td>
<td><strong>4 257</strong></td>
<td><strong>8 905</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Italian National Radon Archive. Data refers to the situation up to 2014)

- These numbers refer only to surveys carried out by national and regional institutes and agencies institutionally involved in the protection from radon.
- Data on surveys carried out by others (e.g. universities) or on measurements not carried out within surveys (i.e. performed on request) are not included.
- Numbers on schools and workplaces refer to buildings and not to rooms. The total number of measured rooms is much higher.
Remedial actions in dwellings, schools, other workplaces

<table>
<thead>
<tr>
<th></th>
<th>Completed</th>
<th>In progress</th>
<th>Planned</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwellings</td>
<td>85</td>
<td>2</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>Schools</td>
<td>162</td>
<td>36</td>
<td>64</td>
<td>262</td>
</tr>
<tr>
<td>Other workplaces</td>
<td>48</td>
<td>2</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>295</strong></td>
<td><strong>40</strong></td>
<td><strong>64</strong></td>
<td><strong>399</strong></td>
</tr>
</tbody>
</table>

(Source: Italian National Radon Archive. Data refers to the situation up to 2014)

- These numbers refer only to remedial actions carried out by institutes and agencies institutionally involved in the protection from radon. Actual total numbers are quite higher.
- The majority of remedial actions have been carried out in schools, for which the Italian legislation requires remedial actions if annual radon concentration is higher than the action level of 500 Bq m⁻³.
Some conclusions and lessons from past Italian experience (1)

- **Results of the regulation on radon in workplaces:**
  - No Regions (except one, recently) declared radon-prone areas => Rn conc. required only in underground workplaces.
  - Among notifications of Rn conc. > AL, effective dose > 3 mSv was declared only in few cases (due to occupancy).
  - Therefore remedial actions were applied mainly in schools.
  - It was impossible to verify fulfilment of notification (required if Rn conc. > AL).
  - In several cases, Rn conc. was measured for a period shorter than 1 y required by legislation.
Some conclusions and lessons from past Italian experience (2)

- Too attention on performing radon surveys and (geo)statistical analysis (Rn-maps was often considered a goal instead of a tool).
- Too small attention to implement effective strategy and tools for remediation.
  - Recommendation for prevention in all new buildings
- Regulation on Rn in workplaces was only partly implemented and resulted to be not effective.
- No national regulation for Rn in dwellings
  - (recommendations are not effective in Italy)
- National Radon Action Plan was not supported by regulation.
Outline

• Past/present legislation ad NRAP (and some lesson learned)
• Forthcoming legislation and NRAP (and challenges)

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• Affordable proxy of national surveys in dwellings
• Cost-effective analysis
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Present/Future: Introduction (1)

- Dir. 2013/59/Euratom deals with both radon at work (initially and partly covered in Dir. 96/29/Euratom) and (finally) radon at home (previously covered in 1990 Recommendations only).
- Requirements on Rn have been harmonized in the general framework of radioprotection.
- However, considerable specific flexibility have been introduced for several radon issues. Besides the requirements in the main text, a great role is given to the National Radon Action Plan (NRAP).
- Recommendations to consider the interaction of radon programs with other programs (on cigarette smoking, indoor air quality, energy conservation) are included in recitals and NRAP.
Present/Future: Introduction (2)

- Doses from radon exposure are usually the highest doses for both workers and population.
- The numbers of exposed persons and regulated environments are much larger than for any other source of ionising radiation exposure.
- Control (reduction) of radon exposure requires expertise usually outside of the RPE.

New regulations, harmonisation, large flexibility, high doses, high number of regulated environments...

=> Many challenges for an optimised protection (and an optimised implementation of the BSS)
Present/Future: Introduction (3)

- Transposition of Directive 2013/59/Euratom has not been completed yet, as well as the preparation of the new NRAP.

- The following slides includes some of the issues (and possible solutions) considered up to now.
A “basic” consideration

• The Directive 2013/59/Euratom deals with basic safety standards:

  Recital 5:

  “...does not preclude, unless explicitly stated in the standards, a Member State from providing for more stringent measures of protection.”

  “As this Directive provides for minimum rules, Member States should be free to adopt or maintain more stringent measures in the subject-matter covered by this Directive, without prejudice to the free movement of goods and services in the internal market...”

• This applies also to requirements on radon exposure
Optimisation in Directive 2013/59/Euratom

Art. 5(b) - Optimisation: Radiation protection of individuals subject to public or occupational exposure shall be optimised with the aim of keeping the magnitude of individual doses, the likelihood of exposure and the number of individuals exposed as low as reasonably achievable taking into account the current state of technical knowledge and economic and societal factors.

Reference Levels in Directive 2013/59/Euratom

Definition 84: “reference level” means in an emergency exposure situation or in an existing exposure situation, the level of effective dose or equivalent dose or activity concentration above which it is judged inappropriate to allow exposures to occur as a result of that exposure situation, even though it is not a limit that may not be exceeded.

Art. 7(1): Member States shall ensure that reference levels are established for emergency and existing exposure situations. Optimisation of protection shall give priority to exposures above the reference level and shall continue to be implemented below the reference level.
Optimisation steps for ICRP

1. **Identify exposures** which warrant specific attention to reduce their magnitude

2. **Influence the entire dose distribution** and shift exposures towards lower values

3. **Reduce inequity**

(adapted from Lecomte “Understanding existing exposure situations.”, Ann. ICRP June 2016)
Action Level vs Reference Level

**Action level for Interventions**

Based on ICRP 60 and 65 (Rn) (Dir. 96/29/Euratom + RP88)

Optimised action only for levels > AL (no action for levels < AL)

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**Reference level for Existing Exposure Situations**

Based on ICRP 103 and 126 (Rn) (Dir. 2013/59/Euratom)

Optimisation with priority for levels > RL (but to be applied also for levels < RL)

(adapted from Lecomte “Understanding existing exposure situations.”, Ann. ICRP 45(Suppl.1), 54–63, 2016).
(See also Bochicchio et al. “Radon reference levels and priority areas considering optimisation and avertable lung cancers”, Radiat.Prot.Dosim.177, 87–90, 2017)
Challenges for radon in workplaces (1)

Setting RL

- Cost/effectiveness evaluations show that a higher RL have a lower effectiveness (global risk reduction) and higher cost/effectiveness.
- Depending on Rn level distribution, a low RL can be difficult to be implemented, especially for existing buildings.
- Possible approaches:
  - a lower RL could be set for future buildings compared with RL for existing ones;
  - some requirements (or recommendation, promotion) could (should, considering the meaning of RL) be introduced also for levels <RL, e.g. for levels >50% of RL.

(this challenge applies also to radon in dwellings)
Challenges for radon in workplaces (2)

Rn concentration measurement

• Problem: Passive detectors tend to overestimate radon concentration during working hours

  => inexpensive (to be applied in many workplaces for a long exposure period) active detectors could be developed to take into account worker occupancy (someones already available).

• Problem: Medium and high Rn levels occur also in areas with lower average Rn levels (although with a lower frequency)

  => measurements should be prioritised in selected areas, but not limited to them.
Challenges for radon in workplaces (3)

Requirements for notified workplaces

- Notification (especially for levels $>\text{RL}$ but $<6 \text{ mSv/y}$) should include information on (failed) remedial actions, so that competent authority can verify appropriateness (but also to avoid a “no action” mis-approach).

- Information on all Rn conc. measurements and remedial actions should be sent to a National Radon Archive, i.e. also for non notified workplaces.

- In fact, these data (and the corresponding ones for dwellings) are necessary to evaluate effectiveness of the regulation (including the National Action Plan).
Challenges for radon in workplaces (4)

Requirements for notified workplaces with Rn exposure corresponding to doses > 6 mSv/y

- Requirements should continue to promote optimisation of worker exposure, including further/stronger attempts to reduce radon concentration and exposure.

- Considering the strong synergism between radon and smoking, information about elevated risk for smokers should be given to workers in all notified workplaces and (at least for doses >6 mSv/y) quitting smoking could be promoted too, as an effective method to reduce lung cancer risk from radon exposure, especially if it is difficult to reduce radon levels.
<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Cigarette smoking and radon (jointly, due to synergism)</td>
<td>2 321 9.1%</td>
<td>316 4.9%</td>
<td>2 637 8.2%</td>
</tr>
<tr>
<td>Radon (among non smokers)</td>
<td>261 1.0%</td>
<td>338 5.2%</td>
<td>599 1.9%</td>
</tr>
<tr>
<td>Cigarette smoking (without Rn)</td>
<td>20 727 80.8%</td>
<td>2 824 43.5%</td>
<td>23 551 73.3%</td>
</tr>
<tr>
<td>Causes other than cigarette smoking and radon</td>
<td>2 330 9.1%</td>
<td>3 017 46.4%</td>
<td>5 347 16.6%</td>
</tr>
<tr>
<td>Totale</td>
<td>25 639 100%</td>
<td>6 495 100%</td>
<td>32 134 100%</td>
</tr>
</tbody>
</table>
Challenges for radon in dwellings

Level of protection; effective policy

• Problem: same RL corresponds to a lower protection than in workplaces (due to higher occupancy in dwellings)

  => a lower RL could be set for dwellings than for workplaces
  => a lower RL could be set for future buildings than for existing ones
  => remedial actions could be required/promoted also for Rn levels < RL

• Problem: experience show that encouragement and information have usually a low (moderate) effect on the rate of remediations.

  => consider also a compulsory approach (instead of a recommendatory one), at least for some situations (e.g. rented houses) (recommended by Int.BSS);

  => availability of sufficient (and proficient) local services for remedial actions is essential.
Some other challenges for optimised implementation

• Preventive measures in all the new buildings
  This approach, compared with requiring preventive measures against Rn only in some areas, is quite effective in reducing global exposure in the long-term.

• Remedial actions in existing buildings are necessary
  Prevention in new buildings is important but protection in existing buildings is necessary as well (also due to low rate of new construction or renovation/reconstruction in European countries).

• Building materials can also contribute to indoor radon
  The relative contribution of building materials as source of indoor radon concentration is more and more significant as RL decreases.
Cost-effectiveness analysis of policies for indoor radon reduction in Italian dwellings

Venoso G.1, Carpentieri C.1, Botti T.2, Trevisi R.2, Leonardi F.2, Buresti G.2, Corfiati M.2, Binazzi A.2, Giovani C.3, Procopio S.4, Vitucci L.5, Cesaroni G.6, Bochicchio F.1

1 National Center for Radiation Protection and Computational Physics – Istituto Superiore di Sanità (ISS)
2 Istituto nazionale per l’assicurazione contro gli infortuni sul lavoro (INAIL)
3 Agenzia Regionale per la Protezione Ambientale della Regione Friuli Venezia Giulia (ARPA-FVG)
4 Agenzia Regionale per la Protezione Ambientale della Regione Calabria (ARPA CAL)
5 Agenzia Regionale per la Protezione Ambientale della Regione Puglia (ARPA Puglia)
6 Dipartimento di Epidemiologia del Servizio Sanitario Regionale del Lazio (DEP Lazio)
Cost-Effectiveness Analysis (CEA) Methods

- A spreadsheet based model was used for CEAs. It was developed by Prof. A. Gray (Oxford Univ.) and largely applied (e.g. in the WHO radon handbook, in the RADPAR European project).

- Effectiveness: evaluated by QALY (Quality Adjusted Life Years).

- Costs: radon concentration measurements, radon remediation and prevention, health costs (e.g., for lung cancer treatment).

- Different scenarios (i.e. policies) corresponds to different input parameters of the model. They depends on the approach of the considered policies (for example, using obligations only, or recommendations only, or a mixture of them).
CEA for existing dwellings
Results – Impact of RL on cost and cost-effectiveness

![Graph showing the impact of remediation rate on QALY gained and cost/QALY gained for different reference levels.](image)
CEA: Conclusions (1)

• For existing dwellings, comparison of CEAs performed on different scenarios/policies highlights that:
  
  • mandatory approach for radon policies is generally more effective in terms of radon-related risk reduction (and more cost-effective, too) than recommendatory approach.
  
  • The values of (some) input parameters (e.g., the remediation rate and the reference level) have a great impact on the effectiveness and cost-effectiveness evaluations:
    
    => choice of RL should be optimised
    
    => acquisition of data and information regarding remedial rate (and other parameters) is necessary to monitor the policy effectiveness and to eventually to update it.
CEA: Conclusions (2)

An approach based on fully preventive measures in all the new dwellings is appealing:

- It follows the optimization principle allowing to reduce the overall mean radon concentration
- It allows to standardize the techniques/protocols used for preventive measures
- It is cheaper than remediation in existing dwellings.

However, in Italy it is not sufficient in terms of reduction of the number of lung cancers attributable to radon exposure:

- The annual rate of new buildings is quite low (moreover, the trend is decreasing in the last years).
- Remediation in existing dwellings is necessary.
Affordable proxy of Rn surveys: conclusions

- **Realization** of a potentially good proxy of a population representative survey by measuring radon concentration in dwellings of a sample of employees of a national company distributed all over the country is feasible and quite affordable.

- **Contacting** selected employees by automatic systems (email + web pages connected with databases) is very convenient and more effective than by mail (although less than door-to-door).

- **Actual representativeness** respect to the general population (as regards radon in dwellings) can (and shall) be checked.
Some final considerations

- Final goal: **optimisation** means to pursue the **reduction of both individual and collective risks**, i.e. the reduction of the number of lung cancers attributable to radon exposure in workplaces and dwellings.

- Regular **evaluation** and validation of policy effectiveness by means of indicators related to such goal is necessary (and required by EurBSS for NRAPs).
Effectiveness evaluation is needed: an example
Useful documents

- IAEA documents
- WHO Handbook on Indoor Radon
- RADPAR recommendations
- Papers
Useful documents

RADPAR recommendations

• The RADPAR (Radon Prevention and Remediation) was an European project funded by the Executive Agency for Health and Consumers (EAHC) of the EU Directorate General SANCO, and carried out in 2009–2012, in the framework of the Health Programme 2008–2013.

• 11 associated partner institutions from 10 European countries (Greece, Germany, UK, France, Italy, Austria, Norway, Finland, Belgium, Czech Rep.)

• 7 collaborating partners from 6 countries (Switzerland, UK, Finland, Spain, Portugal, Ireland) and 1 Int. Organization (WHO)
Useful documents

RADPAR recommendations

- A number of documents were produced within RADPAR

- A major document is a booklet of detailed (and quite comprehensive) recommendations:

  **The RADPAR Recommendations**

  ![Image of RADPAR Recommendations](https://www.researchgate.net/publication/322277816_Radon_prevention_and_remediation_The_RADPAR_Recommendations_Booklet)

*It can be downloaded from:*

https://www.researchgate.net/publication/322277816_Radon_prevention_and_remediation_The_RADPAR_Recommendations_Booklet
The RADPAR recommendations: seven sections

1. Recommendations on radon policy and strategy
2. Recommendations on protocols for indoor radon concentration measurements
3. Recommendations to improve radon risk communication
4. Assessment of potential conflicts between energy conservation in buildings and radon exposure reduction
5. Establishment of measurement protocols for radon control technologies
6. Design of training courses for radon measurement, prevention, remediation
7. Recommendations on analysis of cost-effectiveness and health benefits of radon control strategies
Quantitative evaluation of the lung cancer deaths attributable to residential radon: A simple method and results for all the 21 Italian Regions (Radiation Measurements, 2013)
F. Bochicchio (slide 41 of 44)

Regulation and National Radon Action Plan to optimise protection from radon exposure in workplaces and dwellings in Italy: lessons from the past and challenges for the future

Velingrad (Bulgaria)
9–11 April 2019

IAEA

Istituto Superiore di Sanità
Radon reference levels and priority areas considering optimisation and avertable lung cancers

(Radiation Protection Dosimetry, 2017)
The national radon archive as a useful tool for developing and updating the national radon action plan

(Radiation Protection Dosimetry, 2017)
Last but not least

Special thanks to:

• **Olga** for the important IAEA activities on Rn (and for having involved me in this interesting and useful workshop)

• **Kremena** and **Bistra** for their enthusiastic and perfect local organization

• **Christophe** for his effective and friendly collaboration

• **All of you** for your kind attention and the useful presentation and discussions.
### Annual number of death for lung cancers attributable to Rn in Italy

<table>
<thead>
<tr>
<th>Regione</th>
<th>Casi osservati</th>
<th>Numero di casi stimati</th>
<th>Percentuale dei casi osservati</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stima puntuale</td>
<td>Intervallo di confidenza (95%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stima puntuale</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>558</td>
<td>49</td>
<td>16</td>
</tr>
<tr>
<td>Basilicata</td>
<td>219</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Calabria</td>
<td>665</td>
<td>26</td>
<td>8</td>
</tr>
<tr>
<td>Campania</td>
<td>2 822</td>
<td>372</td>
<td>128</td>
</tr>
<tr>
<td>Emilia - Romagna</td>
<td>2 886</td>
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</tr>
<tr>
<td>Friuli - Venezia Giulia</td>
<td>775</td>
<td>106</td>
<td>37</td>
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<td>Lazio</td>
<td>3 121</td>
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<td>Liguria</td>
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<td>Lombardia</td>
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<td>Molise</td>
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<td>Piemonte</td>
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<td>Toscana</td>
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<td>159</td>
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<tr>
<td>Trentino - Alto Adige</td>
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<tr>
<td>Umbria</td>
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<td>238</td>
<td>79</td>
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<tr>
<td><strong>Italia</strong></td>
<td><strong>32 134</strong></td>
<td><strong>3 237</strong></td>
<td><strong>1 087</strong></td>
</tr>
</tbody>
</table>

(Estimated by ISS, 2010)