Definition of radon priority areas: BSS Art. 103/3 revisited

Bossew P., Petermann E.

German Federal Office for Radiation Protection (BfS), Berlin

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RESPIRE
Radon real time monitoring system

BSS Article 103/3:

Member States shall identify areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level.

Annex XVIII

List of items to be considered in preparing the national action plan to address long-term risks from radon exposures as referred to in Articles 54, 74 and 103:

(2) Approach, data and criteria used for the delineation of areas or for the definition of other parameters that can be used as specific indicators of situations with potentially high exposure to radon.

(6) Strategy for reducing radon exposure in dwellings and for giving priority to addressing the situations identified under point 2.


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Legislation
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DIRECTIVES
Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom
Price: EUR 4
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“significant number”

- From the beginning (2013) there were discussions about the meaning of this apparently cryptic formulation.
- Perhaps it was put like this on purpose to allow flexible interpretation?
- Mostly it was interpreted as
  - “significant fraction” of buildings in an area > RL;
  - “mean over buildings” in an area > RL

compatible with BSS objective?

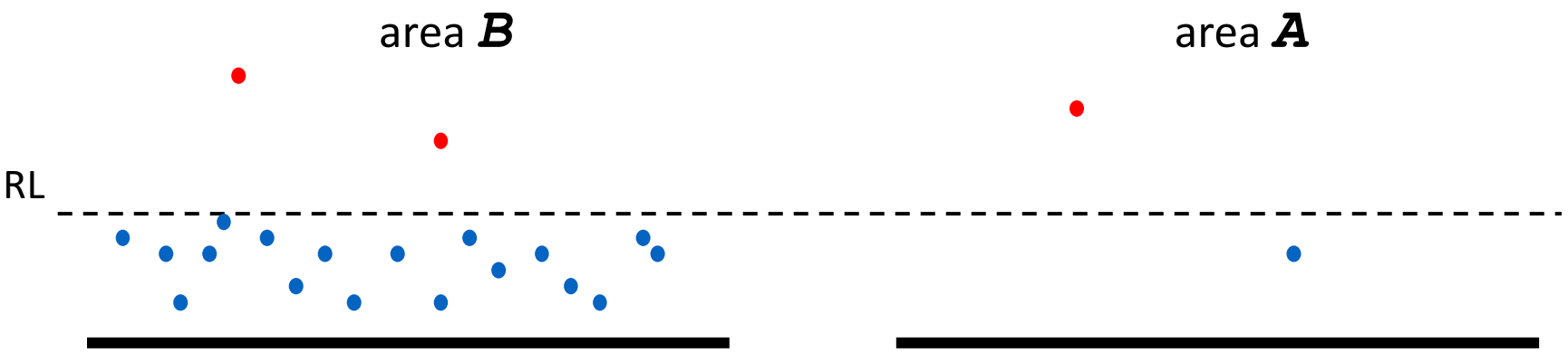
- Conventional interpretation assigns an area a value (mean IRC, probability to exceed a RL) or RPA status (Y/N or several classes) according to its predictors (i.e., IRC or surrogates);
- but irrespective the number of buildings or persons affected.
- This seems partly opposed to the objective of BSS:

- Article 2/2: This Directive applies in particular to: (…) (d) the exposure of workers or members of the public to indoor radon, (…)
- Preamble (23): National action plans are needed for addressing long-term risks from radon exposure.(…)
- Annex XVIII, (13): Long-term goals in terms of reducing lung cancer risk attributable to radon exposure (…)

Problem:

- A sparsely populated area ***A*** (low number of houses) can be RPA, because of high mean IRC or high fraction of houses exceeding RL.
- Still, collective exposure and hence risk related to Rn is low.

- On the other hand, a densely populated area ***B*** (many houses) can be non-RPA, because of low mean IRC or low fraction of houses exceeding RL.
- Still, collective exposure in ***B*** can be higher than in ***A***.



prob(IRC>RL)=2/20=0.1
⇒ RPA status <u>low</u>

prob(IRC>RL)=1/2=0.5
⇒ RPA status <u>high</u>

also mean(IRC) in ***B*** < mean(IRC) in ***A***.

but:
collective risk ~ exposure ~ Σ IRC = <u>high</u>

but:
collective risk = <u>low</u>

According to the conventional interpretation of Art. 103/3 and Annex XVIII (6), one would concentrate Rn policy on area ***A***, but not on ***B***, although the collective risk due to Rn is higher in ***B***.

risk and detriment

- The “detriment” due to Rn exposure, inflicted to society, is the number of lung cancer fatalities.
- This number is proportional to the collective exposure, if LNT is assumed.
- This means that the conventional strategy, i.e. concentrating on area ***A*** (high RPA status, therefore high individual risk, but low number of cases, therefore low collective risk), is not efficient, if the objective is reducing the detriment measured as number of lung cancer fatalities.
- BSS speaks about objective = reducing risk by Rn.

“reducing risk”

- Individual risk? (→ Rn exposure of a person)
- Collective risk? (→ number of people affected)

Objectives of radiation protection

Twofold!

1. Protect individuals from high exposure, to reduce individual risk … also if few persons are concerned.
2. Avoid high exposure to the collective, because the detriment to society is proportional to collective exposure (assuming LNT).

But for Rn: which risk can be avoided at all?

- IRC < outdoor conc. (2 – 20 Bq/m³): impossible
- IRC < 100 Bq/m³ - reasonable given the costs?
  This implies the discussion of how to weigh health vs. costs.

Reference level

- The RL and conventional RPA concept apply to individual exposure
- There is no equivalent of the RL for collective exposure

<u>Open question, therefore:</u>

- Propose a measure of "prioritynes" of action to applied for areas with low individual but high collective risk -- in analogy to the RPA status, which decides about the prioritynes given to action in an area, considering the high rate of individual risk.
- Perhaps ΣIRC/km² ? or Σ(IRC-threshold)/km² ?, where threshold = value which is considered inevitable or unreasonable to be of concern, such as 50 or 100 Bq/m³, or the national mean or median?

Reference and Action Level

- It must be emphasized that RL (as defined in the BSS, IAEA and EU alike) are no AL!
- AL: if exceeded, action must be taken, if not exceeded, no action required.
- RL: exceedance is “inappropriate” (BSS Art.4 (84)), but also if IRC<RL, minimization should be attempted (BSS Art. 7/1: *“Optimisation of protection shall give priority to exposures above the reference level and shall continue to be implemented below the reference level”*).
- However, it seems that in regulatory practice (as laid down in legislation), RL is often practically treated as AL; RL is a juristically complicated thing.

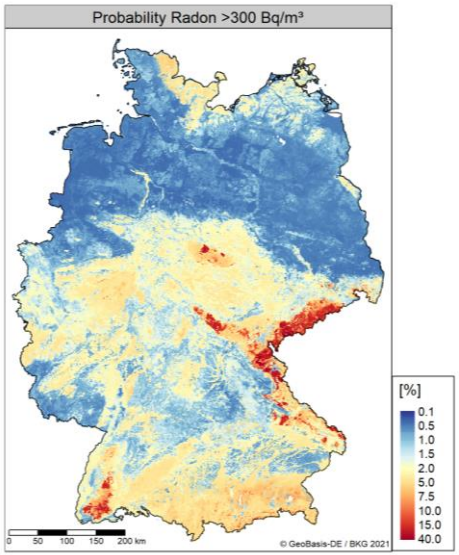
  (Ex.: In German legislation, for workplaces, the RL is understood as AL.)

A real-world example

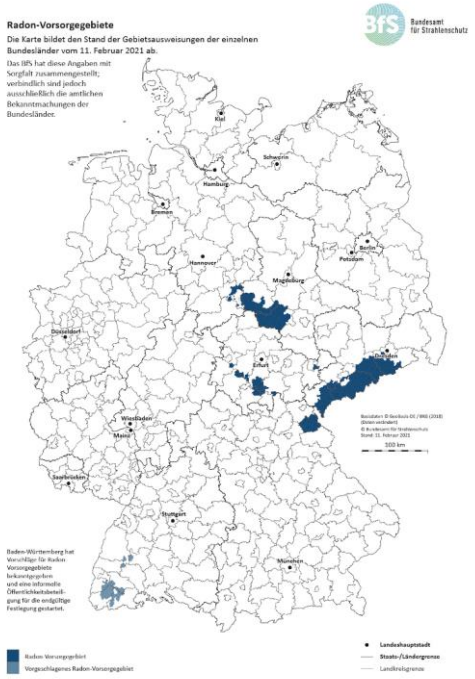
- Calculations from Germany, which motivated these thoughts.
- RPA abstractly defined as areas (municipalities or districts), in which prob(IRC>RL=300 Bq/m^3)>10%.
- The geographical distribution of the probability has been estimated by statistical means (not to be discussed here).
- How the local probability p(x) is transposed into the RPA status of a municipality, is up to the Federal States; it is not necessarily the mean of p(x) over $x \in$ area.

  (This is because by German constitution, while the radioprotection law is on federal level, its implementation is with the Federal States.)
- Prevention also outside RPA: for all new buildings basic Rn isolation required.

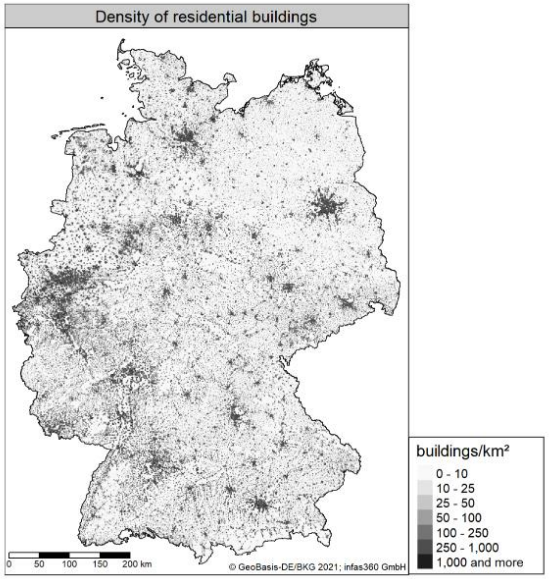
Estimated prob(IRC>300)



"official" RPA defined by the Federal States:



Density of residential buildings:



Estimated number of buildings with IRC>300 within RPA, defined as areas p(IRC>300)>10%, i.e. not the official ones: ~27.000

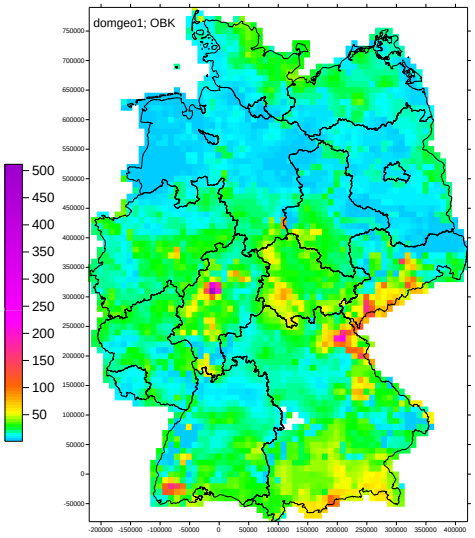
Estimated number of buildings with IRC>300 outside RPA: ~345.000

Estimated annual number of lung cancer fatalities due to Rn inside / outside RPA: ?/?
(Σ 1900 assumed)

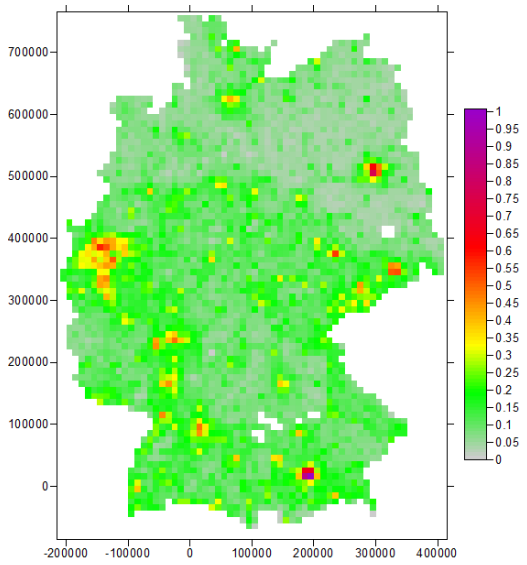
Number attributable to houses with IRC>300 inside / outside RPA: 7/88

Example continued

Neznal-GRP, (different estimation method, coarser resolution)

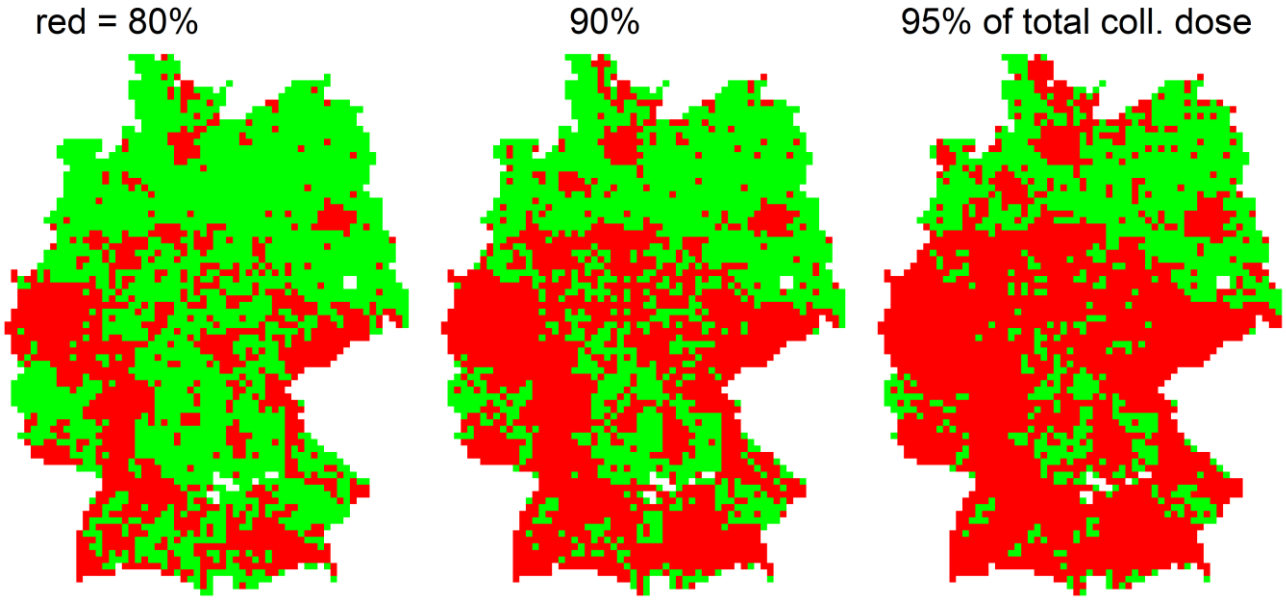


Collective dose per unit area, roughly as GRP × pop. dens. (scaled to [0,1])



Zones which represent different percentages of the total detriment (coll. dose)

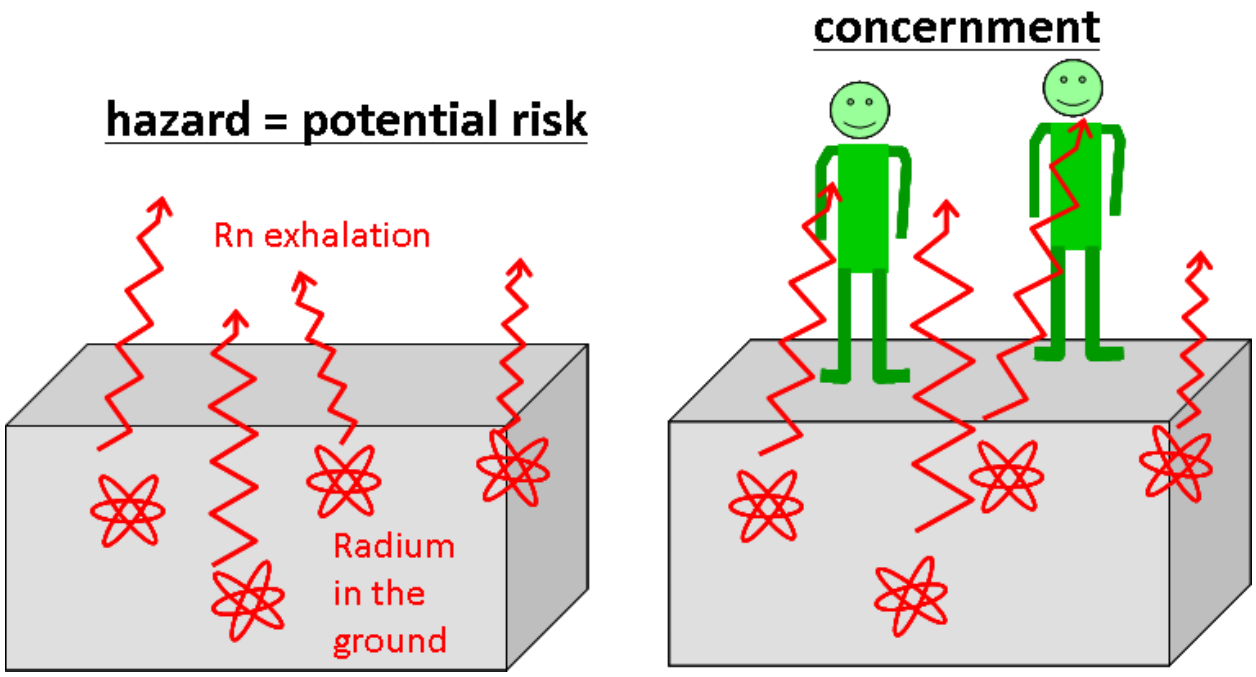
cumulated starting from the cell with the highest coll. dose; the total areas are the smallest possible related to a given percentage.



Hazard and risk, 1

- **Hazard** exists also if nobody is affected or concerned;
- It becomes a **risk**, (= a certain probability of damage), if there is somebody who can be harmed. If there is nobody, evidently there is no risk, even if a physical cause exists.
  (Or in general, any being or thing whose damage should be avoided.)

risk = hazard × concernment



The RPA concept, as conventionally understood, addresses hazard, not risk!

Hazard and risk, 2

A more sophisticated definition exists in Italian Law (National Civil Protection, Law no. 92/2019).

Risk =	(at a location, at a time)
Hazard ×	Probability of ***occurrence*** of a potentially harmful phenomenon
Vulnerability ×	Conditions (environmental, social, economic,…) which determine the ***susceptibility*** of the good which can be harmed (people, community, infrastructure, material assets,…)
Exposure	***Presence*** of this good

In the previous scheme, "concernment" ≈ vulnerability × exposure

Many thanks to Giancarlo Ciotoli who has pointed us to the Italian scheme!

Conclusions 1

- Questioning the usefulness of RL and RPA concepts:
  - @ RL: Even if all buildings with IRC>RL were remediated (neither possible, nor attempted): Reduction of detriment would be insignificant.
  - @ RPA: Most cases lie outside RPA (although the frequency is higher within) $\Rightarrow$ Concentrating on RPA leads to even less significant reduction.
- Possible consequences:
  - Should one propose a new type of RPA which reflects the distribution of detriment instead of the occurrence frequency of high values - i.e., which is concerned about risk instead of hazard, as the conventional RPA concept does?
  - In such “new”-RPA, abatement measures different from “conventional”-RPA would be proposed.
  - “New” and “conventional” RPA concepts are not in contradiction, but are complementary!

Conclusions 2

- A radon reduction strategy which is based on the RL and (conventional) RPA – i.e. hazard – concept only, can reduce individual risk, but is little efficient to reduce the detriment inflicted to the society by Rn exposure.
- It should be discussed how this second aspect: reducing the total detriment or risk due to Rn, can be integrated into a legal framework.
- It seems that the considerations presented here are relatively robust against deviations from LNT, but this has to be investigated further.

The ideas presented here are contributions to the discussion about how efficiency of Rn policy could be improved, but do not represent an official position of the BfS!

Thank you!