ANALYSIS OF THE POSSIBLE RADON PROTECTION STRATEGIES IN RUSSIA

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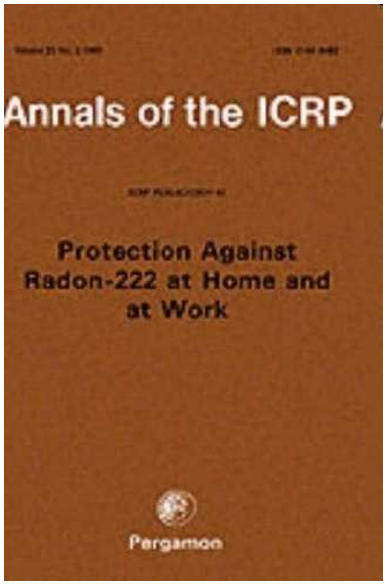
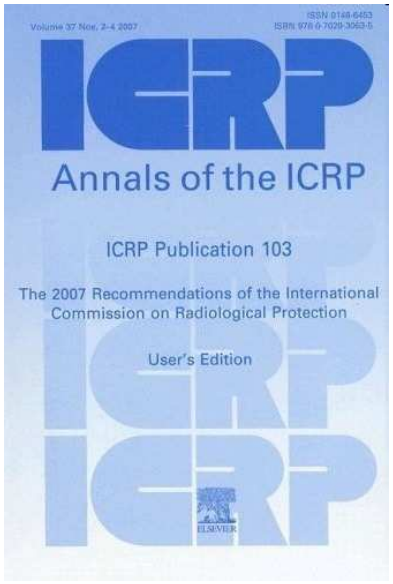
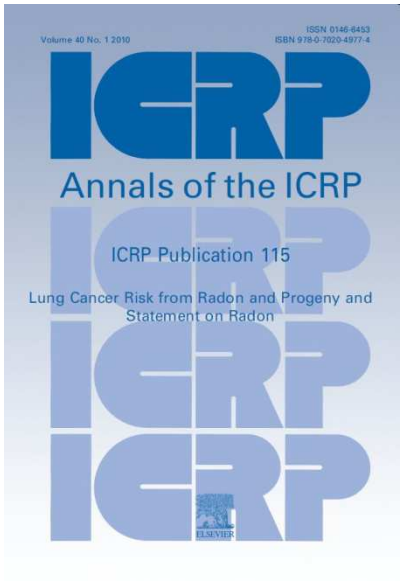
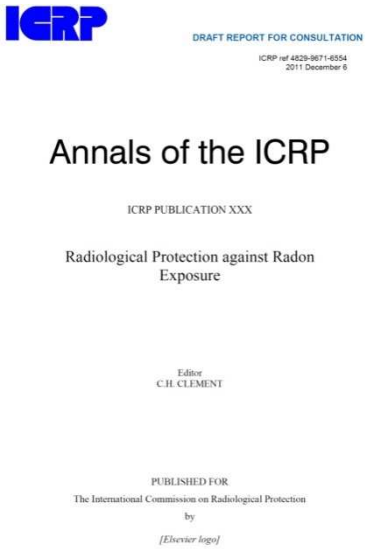
Old and New ICRP Recommendations









- At the present time the general approach to the population radiological protection is presented in ICRP Publication 103.
- These Recommendations are in general continue the policy about radon exposure presented in the ICRP Publication 65.
- ICRP Publication 115 gives the new data on radiation risk due to radon exposure. These data gives the sound basis for the new approaches to radiological protection against radon exposure.
- ICRP presented on site www.icrp.org the draft of new ICRP Recommendations on radiological protection against radon exposure.
- The draft of new Recommendations is completely corresponding to conception of reference levels described in details in ICRP Publication 103

Typical ICRP approach to protection against Rn

- In realization of such strategy the radon levels decreasing should be carried out in buildings with radon concentrations both above and below a reference level.
- In case of the decreasing of radon levels initially below a reference level an optimization process should be used.
- As a result the total population exposure by radon and radon decay products will be decreased and, accordingly, the incidence of lung cancer will also be reduced.

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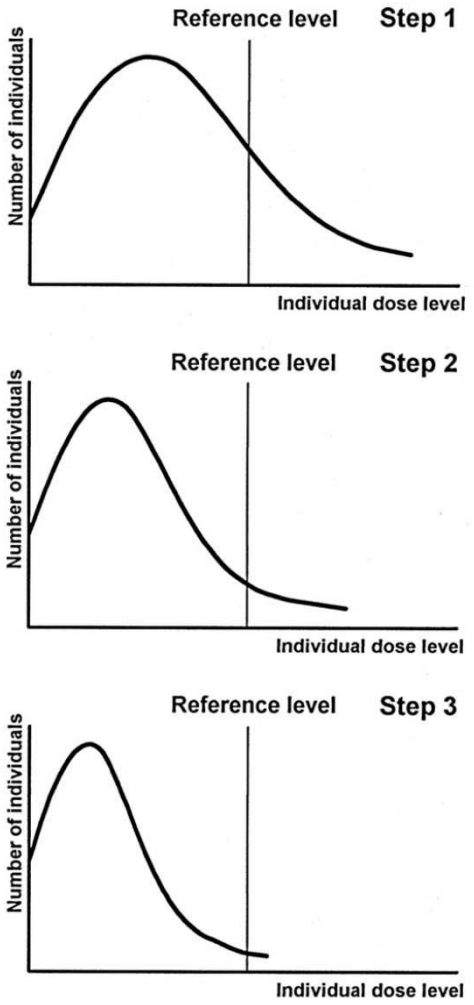

The possible disadvantages of ICRP approach

- The need to conduct the remediation and prevention work in a significant number of buildings
- A long period of the work
- Significant cost of the remediation measures
- Non significant expected decrease of average lung cancer incidence among peoples who live in remediated buildings

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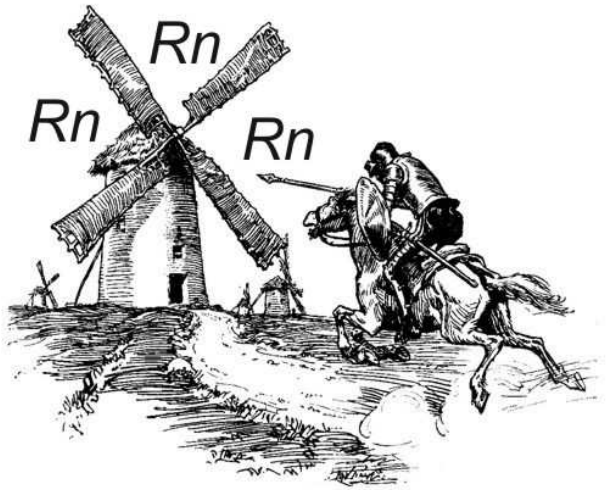

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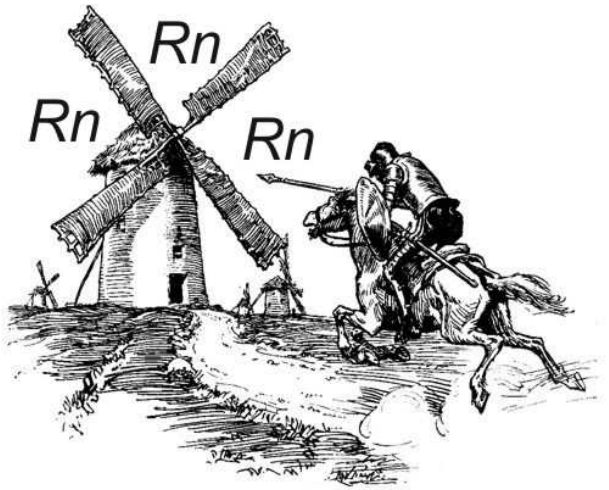
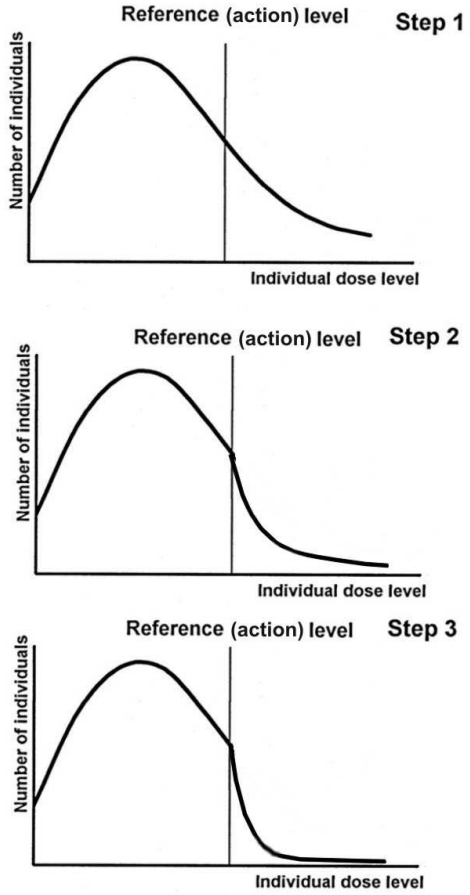


The alternative approach to remediation measures against radon



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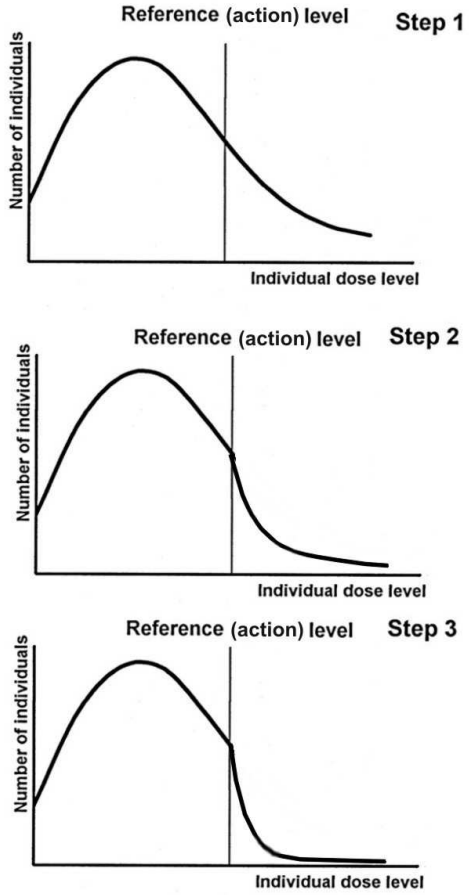
- Focused predominantly on the mitigation measures in the dwellings and public buildings where the average radon levels exceed the reference (action) level



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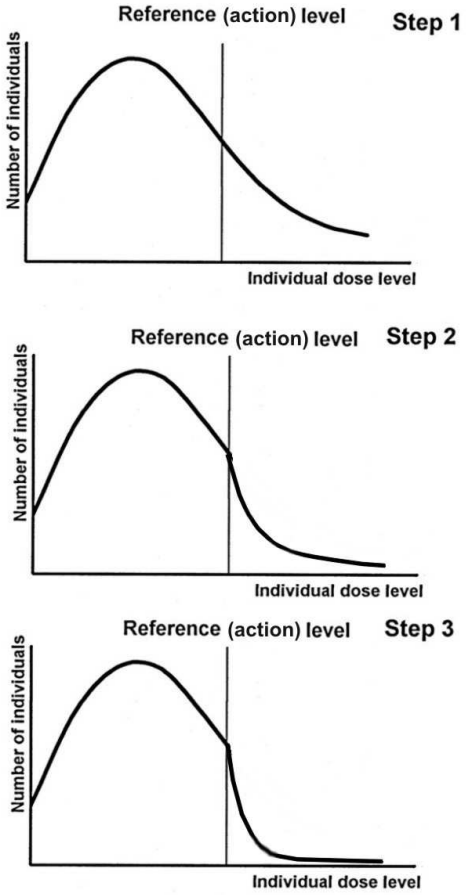

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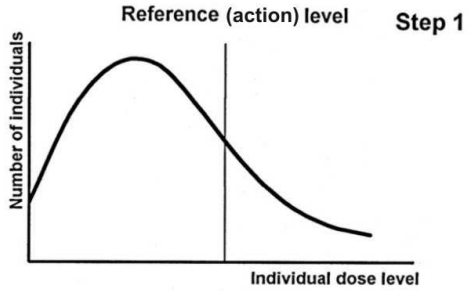
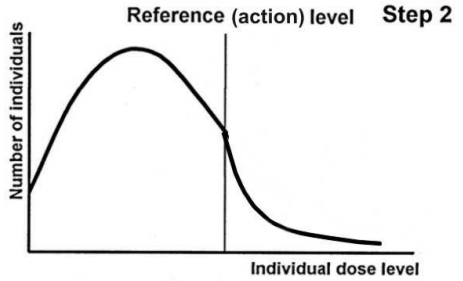
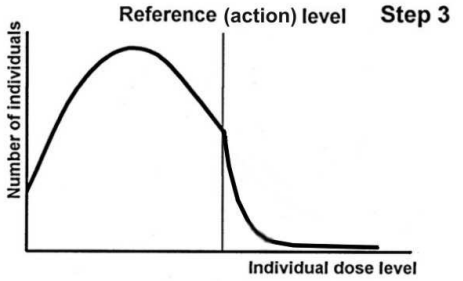
- In the realization of such strategy the radiation risk will be decreased during active remediation measures only for the most exposed part of population
- For the buildings with radon concentrations below reference (action) level the radon decreasing should be conducted only during planned renovations or major overhaul







The comparison of the possible results for these two strategy realization on the example of Russian Federation

- The average levels of radon exposure in Russia were estimated on the base of official statistical data
- The average radon concentration value was recalculated back from average effective dose due to radon exposure 2.2 mSv/year using the conversion coefficients officially adopted in Russia.
- In the Russian Federation there is no statistical data on the nationwide value of such parameter as geometric standard deviation (GSD) of radon concentration distribution.
- The GSD value obtained during our researches in the Ural region was adopted.

Zhukovsky M., Yarmoshenko I., Kiselev S. Combination of geological data and radon survey results for radon mapping. Journal of Environmental Radioactivity 2012. V. 112, P. 1–3.

The estimated parameters of radon exposure in Russian Federation

Parameter	Value
Arithmetic mean Rn concentration, Bq/m^3	76
Geometric mean Rn concentration, Bq/m^3	46
Geometric standard deviation	2.72
Proportion of dwellings with radon concentration above 250 Bq/m^3, %	4.4
Average radon concentration for the dwellings with radon concentration above 250 Bq/m^3	410
Proportion of dwellings with radon concentration above 500 Bq/m^3, %	0.86
Average radon concentration for the dwellings with radon concentration above 500 Bq/m^3	732

Radiation risk assessment

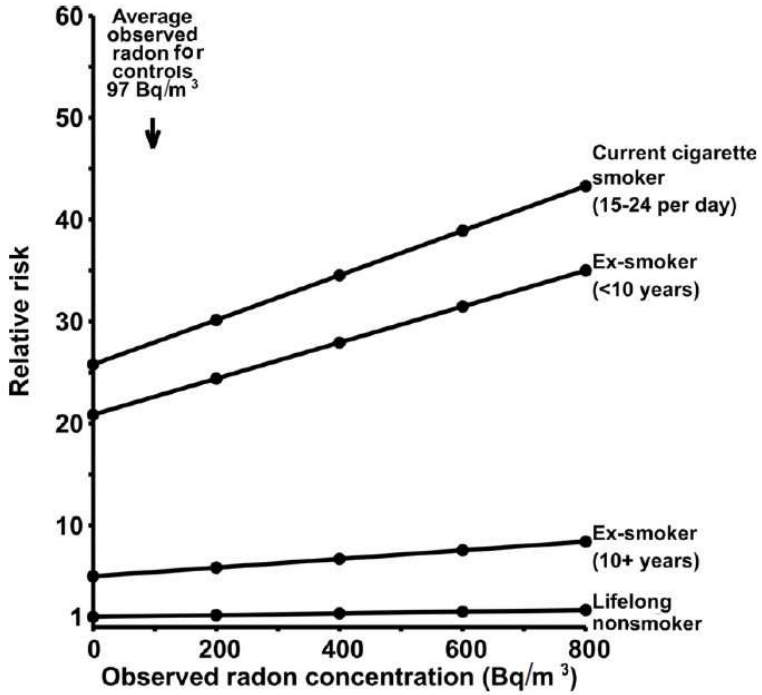
- For the parameters of radon exposure for different population groups the radiation risk of radon induced lung cancer was calculated
- It was assumed that the radon concentration in the mitigated building will not exceed 60 Bq/m^3
- In risk assessment the “WISMUT” model of radon radiation risk was used

Grosche B., Kreuzer M., Kreisheimer M., Schnelzer M., Tschense A. Lung cancer risk among German male uranium miners: a cohort study, 1946–1998. British Journal of Cancer (2006) V.95, P. 1280-1287.

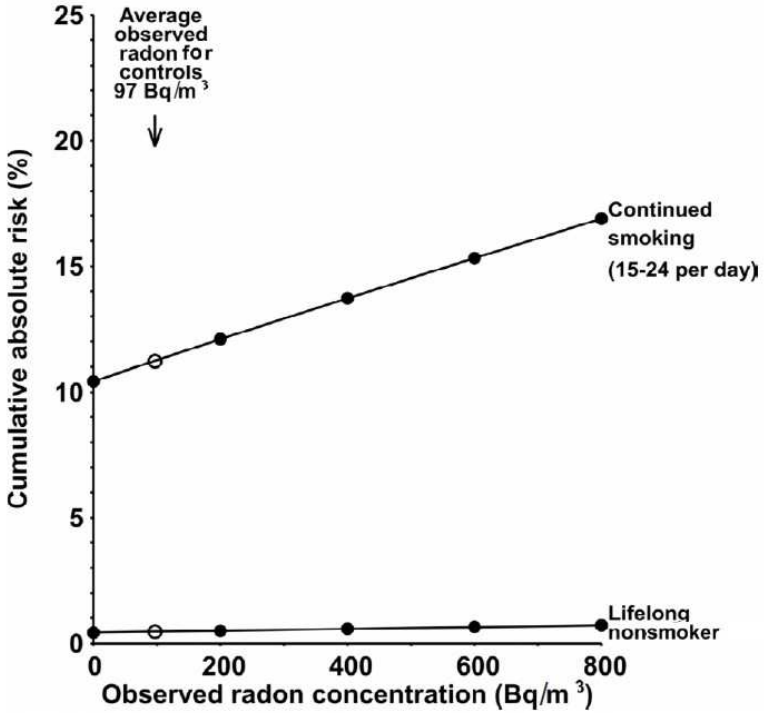
Radiation risk assessment for the different groups in risk of radon exposure

Group at risk	Expected radon induced lung cancer incidence per 100000, year^{-1}		Attributive lifetime risk of radon induced lung cancer, %
	Male	Female	
Population of Russia at whole	12.7	2.2	14.7
Population living in dwellings with radon concentration above 250 Bq/m^3	66.6	12.1	48.2
Population living in dwellings with radon concentration above 500 Bq/m^3	115.3	21.6	62.3
Population which will live in mitigated dwellings	10.0	1.7	11.6
Population of Russia at whole after the mitigation of the dwellings with radon concentration above 250 Bq/m^3 (unreal)	10.1	1.8	12.2
Population of Russia at whole after the mitigation of the dwellings with radon concentration above 500 Bq/m^3 (practically unreal)	11.7	2.1	13.8
Population of Russia at whole after the mitigation of the 25% dwellings with radon concentration above 500 Bq/m^3 (realistic estimation)	12,4	2,2	14,8
Reducing the concentration of radon in the country twice (unreal)	6.4	1.1	7.9

We shouldn't forget about main cause of lung cancer incidence - *smoking* and its interaction with radon exposure



Risk of lung cancer relative to that of lifelong nonsmokers with no radon exposure by the observed radon concentration.



Cumulative risk of death from lung cancer by 75 years of age for various smoking histories by the observed radon concentration.

Darby S., Hill D., Deo H., Auvinen A., Barros-Dios J. M. et. al. Residential radon and lung cancer – detailed results of a collaborative analysis of individual data on 7148 persons with lung cancer and 14208 persons without lung cancer from 13 epidemiologic studies in Europe. Scand. J. Work Environ. Health. 2006. V. 32. Suppl. 1. P. 1-84.

Radon and smoking risk assessment

- It was assumed that relative risk of radon induced lung cancer is 16% per 100 Bq/m^3 of lifetime radon exposure in dwellings [Darby et.al., 2006] .
- It was assumed that relative risk for smokers correspond to 13.2 for men and 5.8 for women [Darby et.al., 2006]. Such approach gives the possibility to estimate influences of different risk factors separately.
- The data on nationwide lung cancer incidence (73.9 and 13.2 $year^{-1}$ per 100000 for men and women respectively) and smoking prevalence (61% for men and 15% for women) in Russia were used.

The assessment of lung cancer incidence under combine influence of smoking and radon

Group at risk	Expected radon induced lung cancer incidence per 100000, year^{-1}		Attributive lifetime risk of radon induced lung cancer, %
	Male	Female	
Population of Russia at whole			
Spontaneous lung cancer	7.81	6.83	10.8
Radon but not smoking	0.94	0.82	
Smoking but not radon	58.2	4.92	
Combination of smoking and radon	7.03	0.59	
Sum radon induced incidence	7.97	1.42	
Total lung cancer incidence	73.9	13.2	
Population living in dwellings with radon concentration above 500 Bq/m^3			
Spontaneous lung cancer	7.81	6.83	54.0
Radon but not smoking	9.16	8.00	
Smoking but not radon	58.2	4.92	
Combination of smoking and radon	68.2	5.76	
Sum radon induced incidence	77.3	13.8	
Total lung cancer incidence	143.3	25.5	

The assessment of lung cancer incidence under combine influence of smoking and radon (2)

Group at risk	Expected radon induced lung cancer incidence per 100000, year^{-1}		Attributive lifetime risk of radon induced lung cancer, %
	Male	Female	
Population of Russia at whole after the mitigation of the dwellings with radon concentration above 250 Bq/m^3			
Spontaneous lung cancer	7.81	6.83	8.8
Radon but not smoking	0.75	0.66	
Smoking but not radon	58.2	4.92	
Combination of smoking and radon	5.58	0.47	
Sum radon induced incidence	6.3	1.1	
Total lung cancer incidence	72.3	12.9	
Reducing the concentration of radon in the country twice (unrealistic estimation)			
Spontaneous lung cancer	7.81	6.83	5.7
Radon but not smoking	0.47	0.41	
Smoking but not radon	58.2	4.92	
Combination of smoking and radon	3.51	0.30	
Sum radon induced incidence	4.0	0.7	
Total lung cancer incidence	70.0	12.5	

The assessment of lung cancer incidence under combine influence of smoking and radon (3)

Group at risk	Expected radon induced lung cancer incidence per 100000, year^{-1}		Attributive lifetime risk of radon induced lung cancer, %
	Male	Female	
Population of Russia at decreasing smoking prevalence to 50% for men and 10% for women			
Spontaneous lung cancer	7.81	6.83	10.8
Radon but not smoking	0.94	0.82	
Smoking but not radon	47.7	3.28	
Combination of smoking and radon	5.76	0.40	
Sum radon induced incidence	6.7	1.2	
Total lung cancer incidence	62.2	11.3	

Results of risk assessment

- The risk for restricted population groups living at high radon concentrations is unacceptably high.
- Therefore the mitigation measures aimed on reducing the radon concentrations in the buildings where radon reference level is exceeded can be justified at the initial stages of national radon policy.
- The focusing of technical and financial forces on the mitigation of the buildings with unacceptably high radon concentrations leads to the reducing of the risk both for selected groups of population (especially) and to the population at whole.
- Nevertheless even large-scale radon mitigation measures are unable to provide a significant reduction in total lung cancer incidence.
- Other methods such as anti-tobacco campaign can be considerably more effective and less expensive on nationwide level.

CONCLUSIONS

- The ICRP Recommendations on establishing radon reference levels can be effective mechanism in decreasing of population exposure by radon and its decay products.
- A significant reduction of the national average radon concentration can be achieved only by large-scale mitigation of existing buildings and the total radon accumulation prevention in designed and constructed buildings. According to our estimates this process will require at least 50 years.
- Even large-scale measures to reduce radon levels in buildings are unable to cause a significant reduction in national lung cancer incidence. The significant reduction of radon induced lung cancer after mitigation can be expected only for restricted population groups living at high radon concentrations.
- In the planning a national policy to reduce the incidence of lung cancer should be considered as measures to reduce radon levels and other more effective measures, such as anti-smoking actions.

Thank you for attention