Radon in the indoor air environment

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Surveillance of the Territory & Natural Radiation

FANC

Federal Agency for Nuclear Control

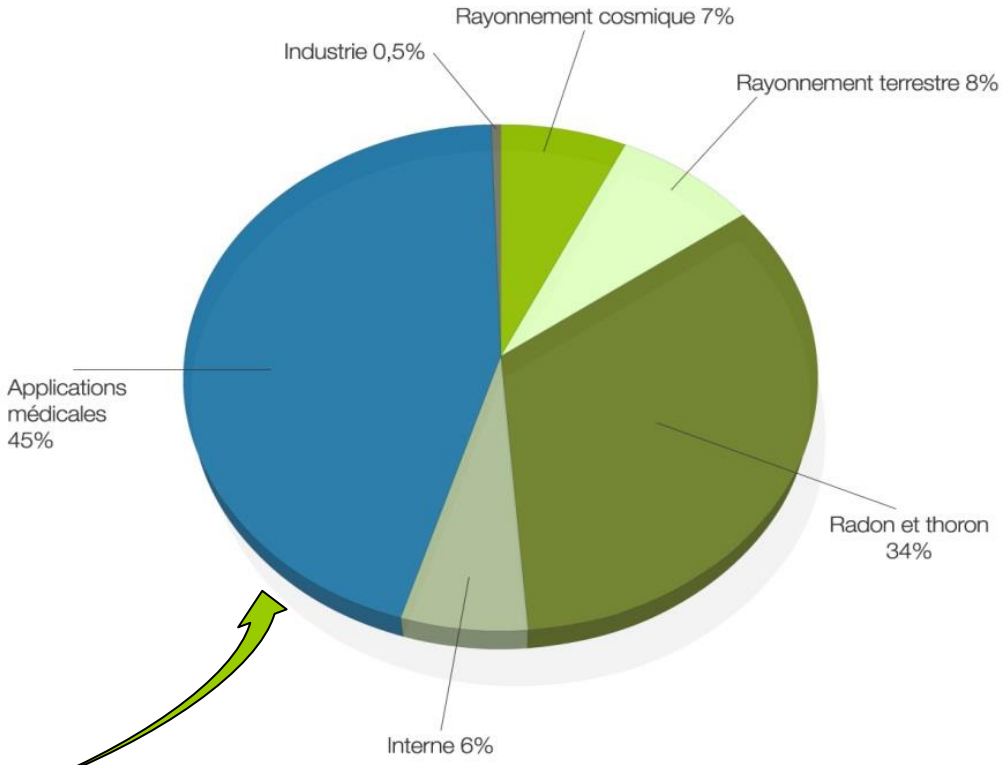
Protection of the **population**, the **workers** and the **environnement** against the dangers from ionising radiation

- **150 collaborators**

(engineers, physicians, physicists, …)

- 6 points of attention:
  - Nuclear **Installations**
  - Radioactive **waste**
  - **Security**
  - **Transport**
  - Protection of **health**
  - **Surveillance** of the territory

  and natural radiation



Contents

- Radon related risk
- Radiation protection legislation and radon
- The national Radon Action Plan
- Consequences
- Conclusions

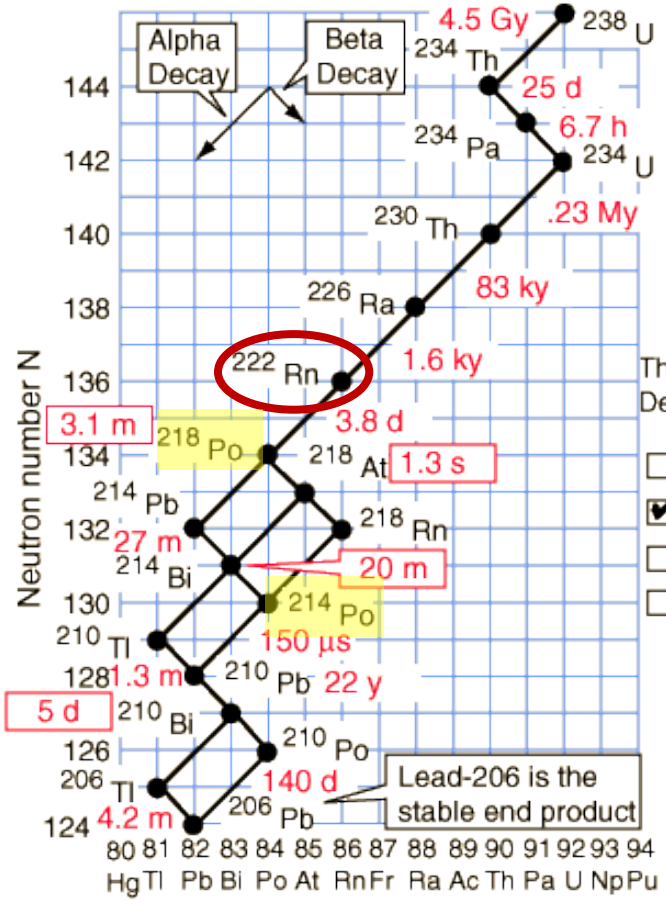
Properties of radon

Gas

- Natural (from radium and uranium)
- tasteless
- colorless
- No smell
- **Radioactive**

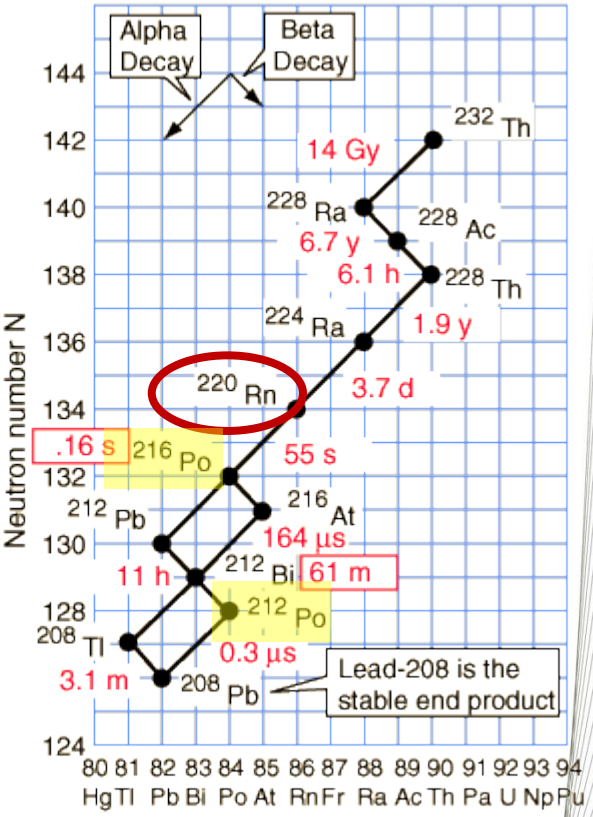
The Uranium-238 Decay Series

- [ ] ^{235}U Series
- [ ] ^{232}Th Series
- [x] ^{238}U Series
- [ ] ^{237}Np Series



The Thorium-232 Decay Series

- [ ] ^{235}U Series
- [x] ^{232}Th Series
- [ ] ^{238}U Series
- [ ] ^{237}Np Series



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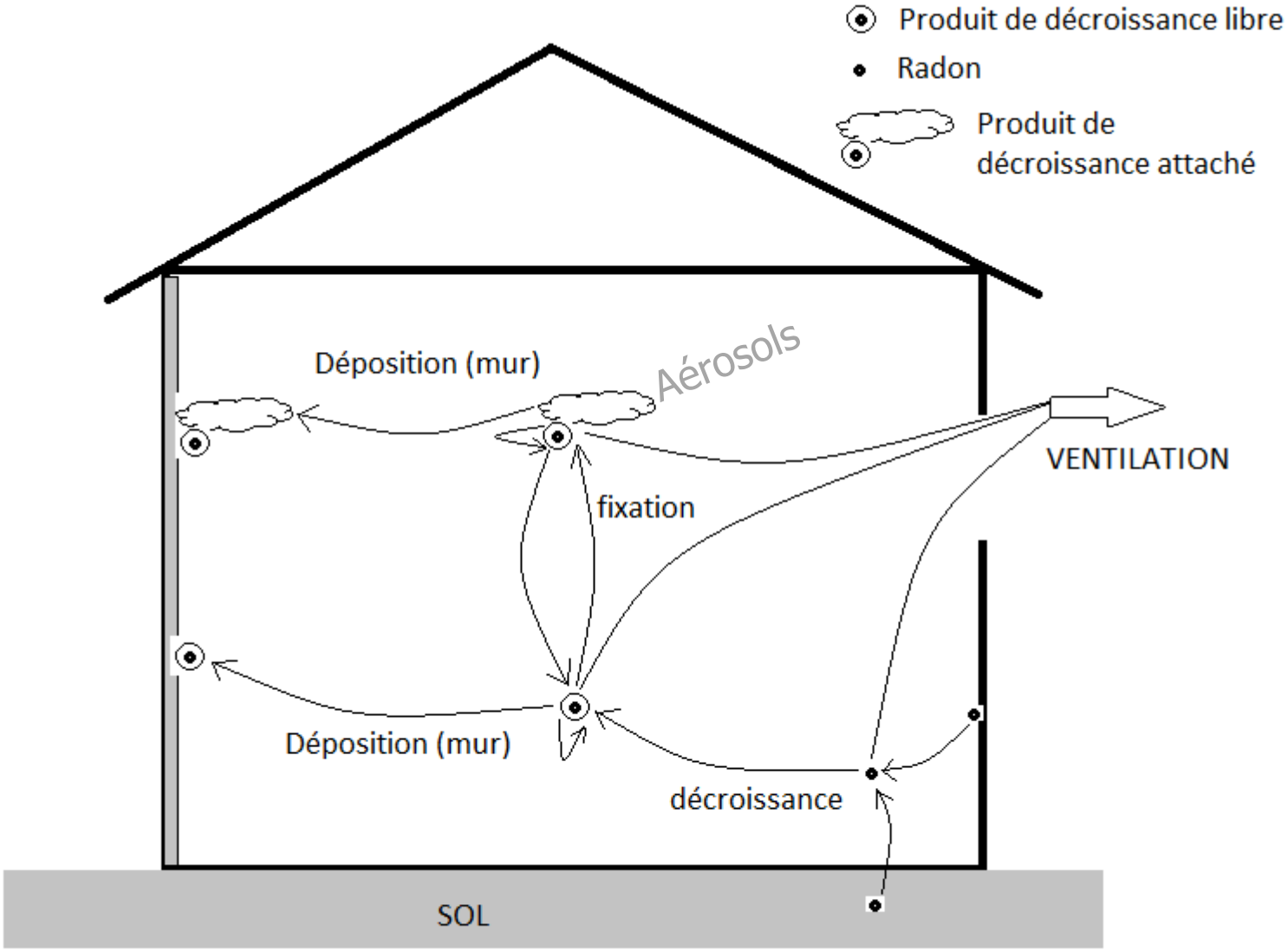

Produit de décroissance libre
Radon
Produit de décroissance attaché
Déposition (mur)
Aérosols
VENTILATION
fixation
Déposition (mur)
décroissance
SOL

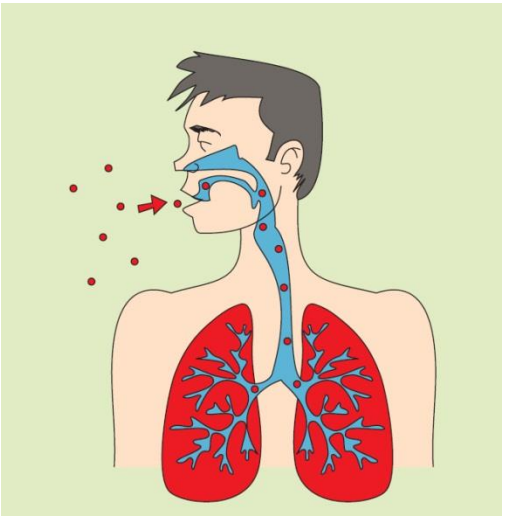
HENCE

- Short living progeny cause the health risk, depending on the PAEC (potential alpha energy concentration) in J/m³. This is linked to

$$EEC = 0{,}105 * C(^{218}Po) + 0{,}515 * C(^{214}Pb) + 0{,}380 * C(^{214}Bi)$$

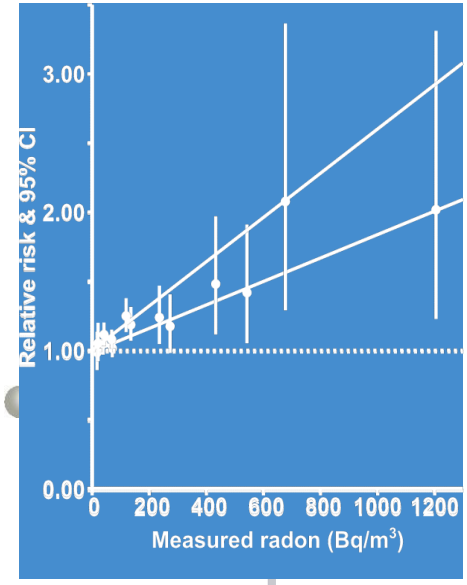
$$F = \frac{EEC}{C(Rn)}$$

- F < 1 (deposition and ventilation) and = 0,4 for dwellings, 0,6 for workplaces.
- There is a unattached and an attached fraction



Radon inhalation increases lung cancer risk

Meta-EPI study in 13 countries (1994-2004)



Concentration Radon (Bq/m^3)	Cancers pulmonaire par 1000 NON-fumeurs	Cancers pulmonaire par 1000 fumeurs
0	4,1	101
100	4,7	116
200	5,4	130
400	6,7	160
800	9,3	216

Darby *et al.*, 2005

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National legislation

Based on EU recommendations

ARBIS (KB 20/07/2001)

- Art. 4 en 9: control workplaces exposed to NORM and radon
- Art. 20 (workplaces): dose level of 3 mSv/y or 800 kBqh/m³
- Art. 70: define radon-prone areas and control radon in dwellings and workplaces here
- Art. 72bis: intervention at existing exposure situation: mitigation or monitoring/control system

- NEW issues to implement (2013/59/euratom), by 2018:
  - Reference level (300 Bq/m³)
  - Planned exposure situation, justification of the protection, Radon action plan, building materials

Art 4: Work activities at risk

In general:

- Mines and caves
- Underground workplaces

In radon prone areas:

- Schools, kindergardens, daycare centers
- Buildings with public access
  - administrations, libraries, medical centers

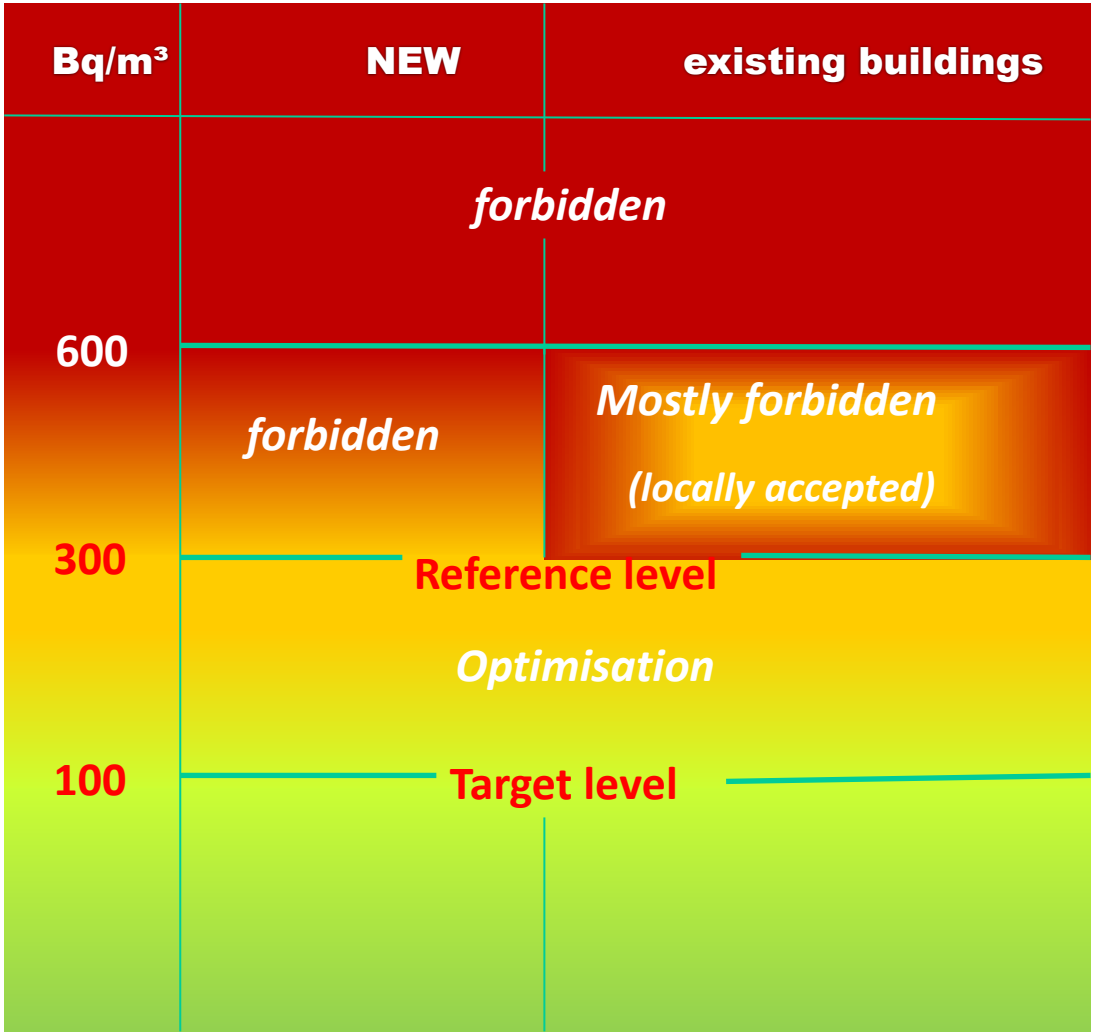
Perspectives

- AL (sensu EC 90/143/euratom) of 400 Bq/m³ for new buildings and 200 Bq/m³ for existing buildings. Recommendation (also High health Council) for the public.
- EC Directive 96/29/euratom was implemented in the Radiation Protection regulation (ARBIS/RGPRI) corresponding to an annual dose of 3 mSv for workers (2000h) exposure (7000h), following UNSCEAR 2000:
  - EEC 9 nSv per Bqh/m³
  - 800 kBqh/m³ for workplaces
- ICRP 103 (2007) lowered dcc, and ICRP statement 2009 to
  - 30 Bq/m³ for 1 mSv per year (residential)
  - 100 Bq/m³ for 1 mSv per year (occupational)
- ICRP working group TG81:
  - Between 15 and 25 Bq/m³ for 1 mSv/y (residential)
  - for work places: ~35 Bq/m³ for 1 mSv/y
- Follow new EC BSS:
  - Art. 74: reference level 300 Bq/m³ (10 mSv per year) for residential exp. maximum
  - Art. 53: 300 Bq/m³ for work places (~3 mSv per year)
  - Art. 35, regulate as planned exposure if > 6 mSv/y

FANC Radon Action plan: Objectives

- **Long term**: general prevention for new buidlings (desigh level of 100 Bq/m³)
  ⇒ substantial reduction of LC-incidence

- **Short term**: remediation of high levels
  ⇒ trace buildings with high exposure and remediate buildings above the Action Level (AL=400 Bq/m³ corresponding to 10 mSv/y


Bq/m³
NEW
existing buildings
forbidden
600
forbidden
Mostly forbidden
(locally accepted)
300
Reference level
Optimisation
100
Target level

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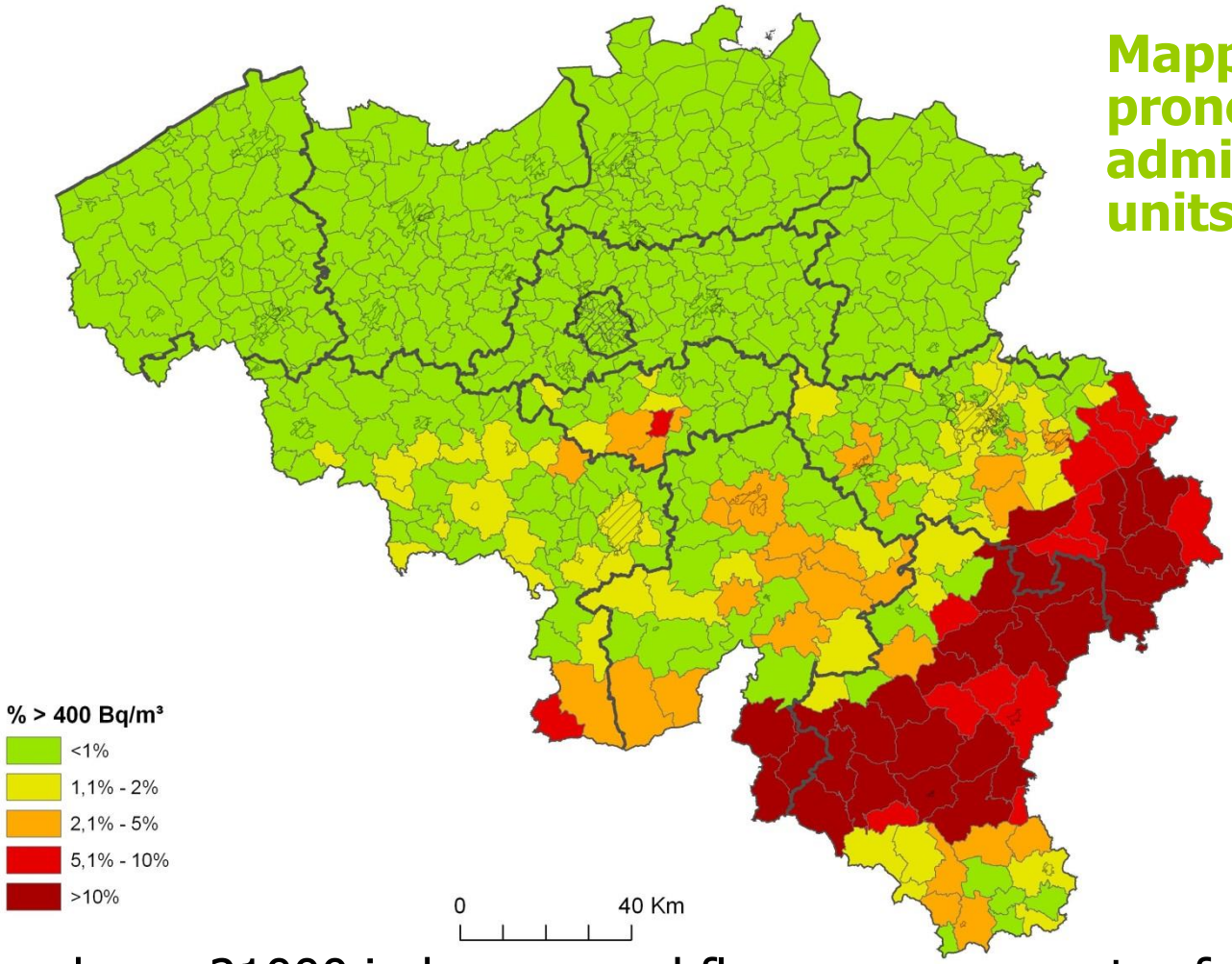
	Population	dwellings	AM	MED	GM	GSD	% >100	% >200	%>300	% >400	% >800
Belgium	10584534	3742000	57	44	46	1.7	10.0	2.1	0.9	0.6	0.2
Wallonia	3435879	1325000	84	60	75	1.7	26.0	4.5	2.6	1.6	0.4
Flanders	6117440	2191000	44	37	36	1.2	3.2	0.1	0.05	0.0	0.0
Brussels	1031215	226000	44	37	36	1.2	4.0	0.1	0.1	0.0	0.0
RPA	376568	130000	220	127	137	1.9	43.0	33.0	17.0	13.0	4.3

	dwellings	>100	>200	>300	>400	>800
Belgium	3742000	360000	84000	36000	21000	5600
Wallonia	1325000	280000	79000	35000	21000	5600
Flanders	2191000	70000	some	some	0	0
Brussels	226000	9000	5000	some	0	0
Radon prone areas	130000	56000	43000	22000	17000	5500

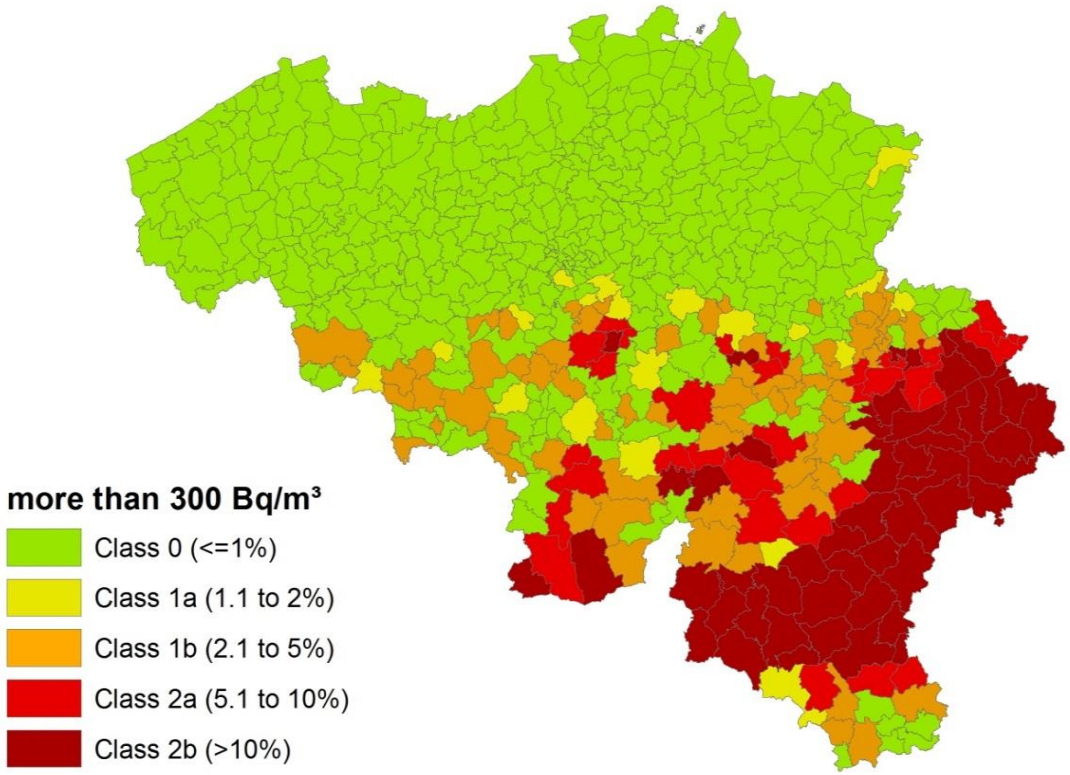
	LC risk NS	LC risk S	LC NS	LC S	total	Due to radon
Belgium	4.4	108.4	399	6558	6958	477 (27 NS and 450 S) (7%)
Wallonia	4.5	113.1	135	2221	2356	252 (14 NS and 238 S) (11%)
Flanders	4.3	107.0	228	3740	3967	222 (13 NS and 209 S) (6%)
Brussels	4.3	107.0	38	630	669	37 (2 NS and 35 S) (6%)
Radon prone areas	5.0	122.0	16	263	279	48 (3 NS and 45 S) (17%)
No radon*	4.1	101.0				

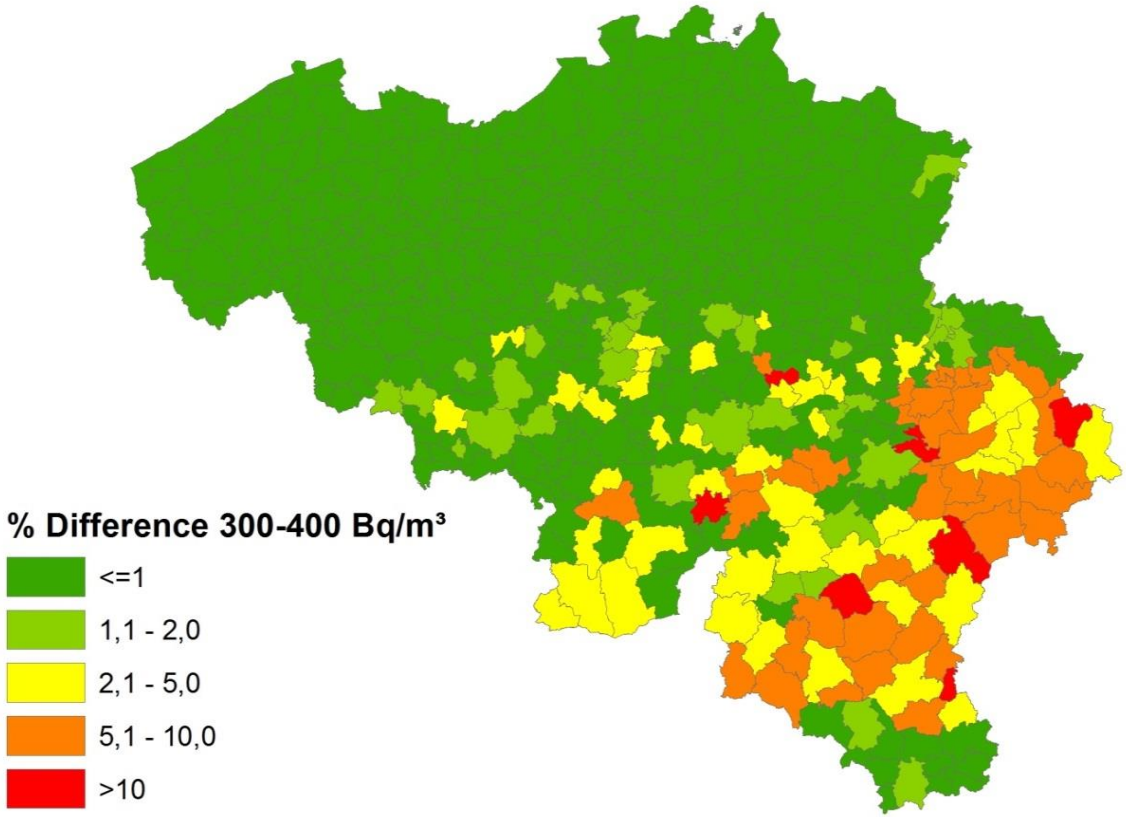
Mapping radon prone areas of administravive units



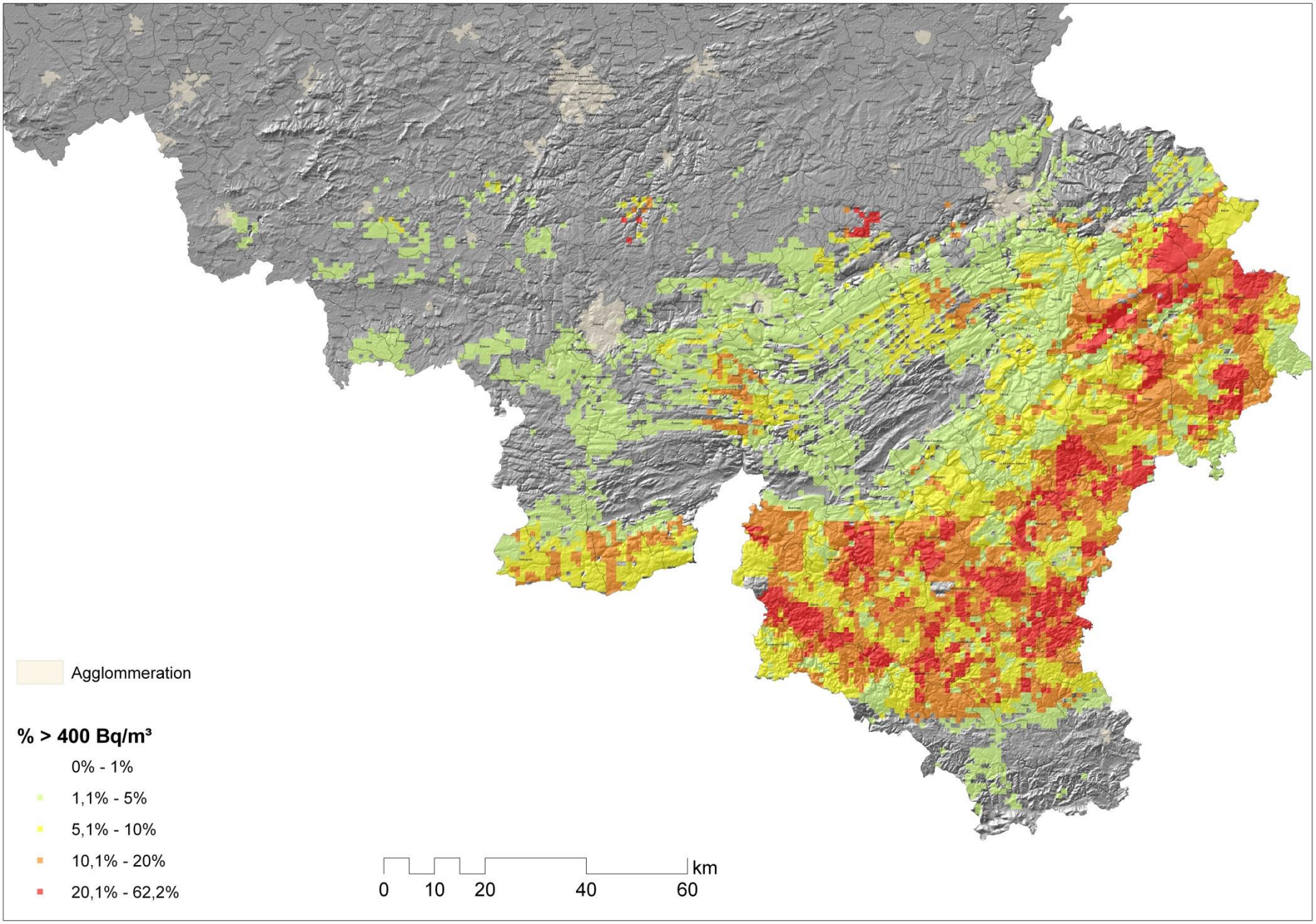
- Based on ~21000 indoor ground floor measurements of single family houses (excluding flats) = conservative statistics
- Legislative purposes:
  - radon region 2 (>5% dwellings > AL (400 Bq/m³) radon measurements in workplaces mandatory
  - Graded approach of radon prevention in new dwellings

Perspectives for the new reference level





	class 2 at 400 Bq/m³	class 2 at 300 Bq/m³
# municipalities	45	81
# dwellings	20k	36k
# workplaces	1,5k	2,5k
population	270k	730k


Agglommeration
% > 400 Bq/m³
0% - 1%
1,1% - 5%
5,1% - 10%
10,1% - 20%
20,1% - 62,2%
0
10
20
40
60
km

FANC Radon action plan

5 fields:

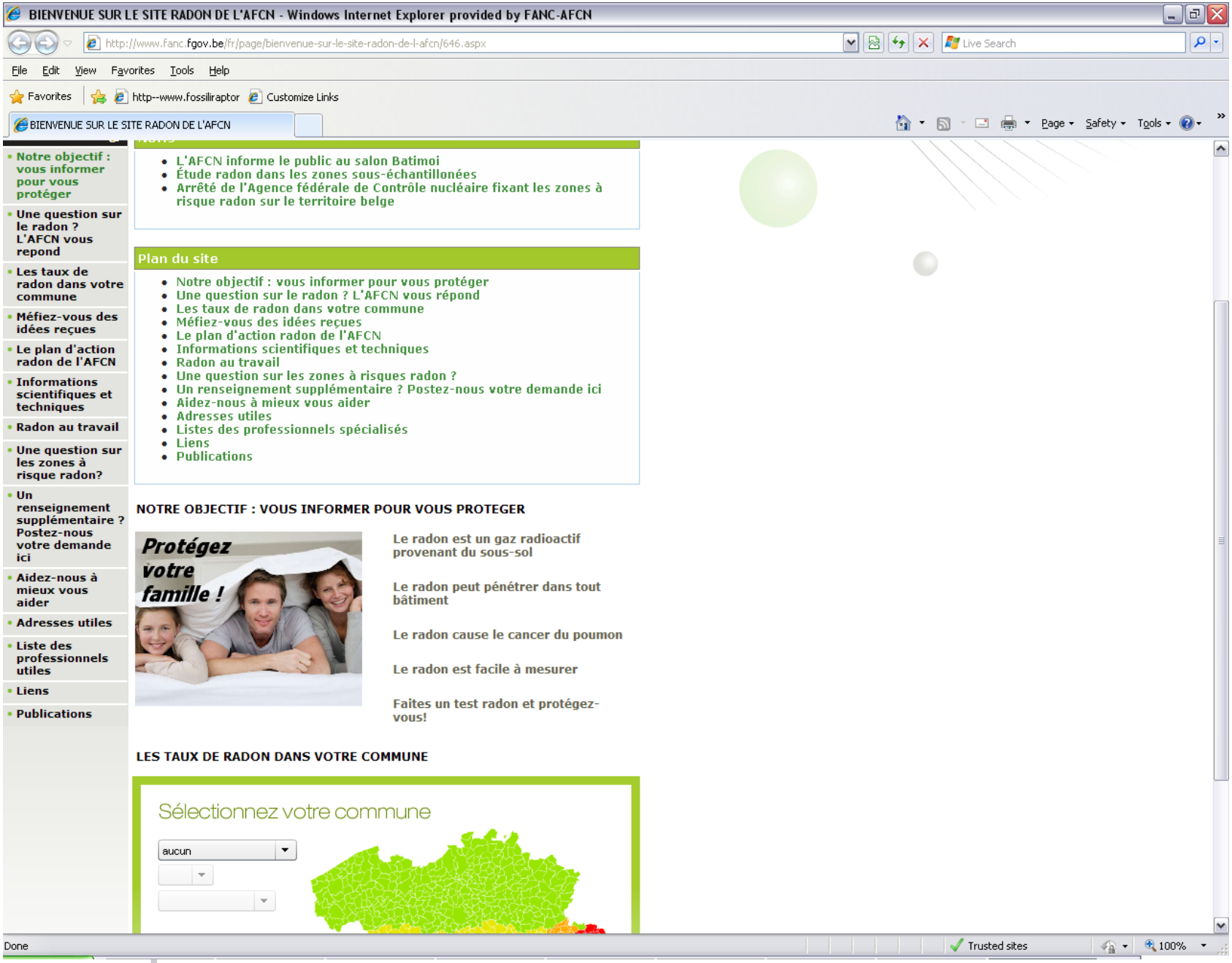
1. Risk Management
   - Strategy and objectives
   - Cooperation with local governments
   - Communication Plan
2. Measurement campaigns (in coop. with local partners)
   - Indoor in dwellings and workplaces
3. Regulations
   - Procedures and directives
     - Definition of risk areas / (interactive) mapping
     - Radon measurements in work places
4. Public Awareness and communication
   - Road-shows, brochures, flyers, web-site, radon day, training courses for building professionals, …
5. Data Management
   - Development of a radon database and mapping

REMEDIATION

- Stimulate remediation trough
  - information sessions
  - Training courses for building professionals
  - Free control test (after remediation)
  - Free test extractors

PREVENTION

- Negotiate with local governments to include radon preventive measures in the building code
- Provide detailed scale radon maps for new builders
- Train local governments to provide radon info for new builders
- Distribute brochures for new builders
- Train architects and building professionals


BIENVENUE SUR LE SITE RADON DE L'AFCN - Windows Internet Explorer provided by FANC-AFCN
http://www.fanc.fgov.be/fr/page/bienvenue-sur-le-site-radon-de-l-afcn/646.aspx
Live Search
File Edit View Favorites Tools Help
Favorites
http--www.fossiliraptor
Customize Links
BIENVENUE SUR LE SITE RADON DE L'AFCN
Page Safety Tools
Notre objectif : vous informer pour vous protéger
Une question sur le radon ? L'AFCN vous repond
Les taux de radon dans votre commune
Méfiez-vous des idées reçues
Le plan d'action radon de l'AFCN
Informations scientifiques et techniques
Radon au travail
Une question sur les zones à risque radon?
Un renseignement supplémentaire ? Postez-nous votre demande ici
Aidez-nous à mieux vous aider
Adresses utiles
Liste des professionnels utiles
Liens
Publications
L'AFCN informe le public au salon Batimoi
Étude radon dans les zones sous-échantillonées
Arrêté de l'Agence fédérale de Contrôle nucléaire fixant les zones à risque radon sur le territoire belge
Plan du site
Notre objectif : vous informer pour vous protéger
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Liens
Publications
NOTRE OBJECTIF : VOUS INFORMER POUR VOUS PROTEGER
Protégez votre famille !
Le radon est un gaz radioactif provenant du sous-sol
Le radon peut pénétrer dans tout bâtiment
Le radon cause le cancer du poumon
Le radon est facile à mesurer
Faites un test radon et protégez-vous!
LES TAUX DE RADON DANS VOTRE COMMUNE
Sélectionnez votre commune
aucun
Done
Trusted sites
100%

Radon prone areas?

FANC decree from 10 August 2011:

Define the areas with increased radon risk

[C − 2015/00733]

30 NOVEMBRE 2015. — Arrêté de l'Agence fédérale de Contrôle nucléaire fixant les zones à risque et les zones visées respectivement au article 4 et article 70 de l'arrêté royal du 20 juillet 2001 portant règlement général de la protection de la population, des travailleurs et de l'environnement contre le danger des rayonnements ionisants

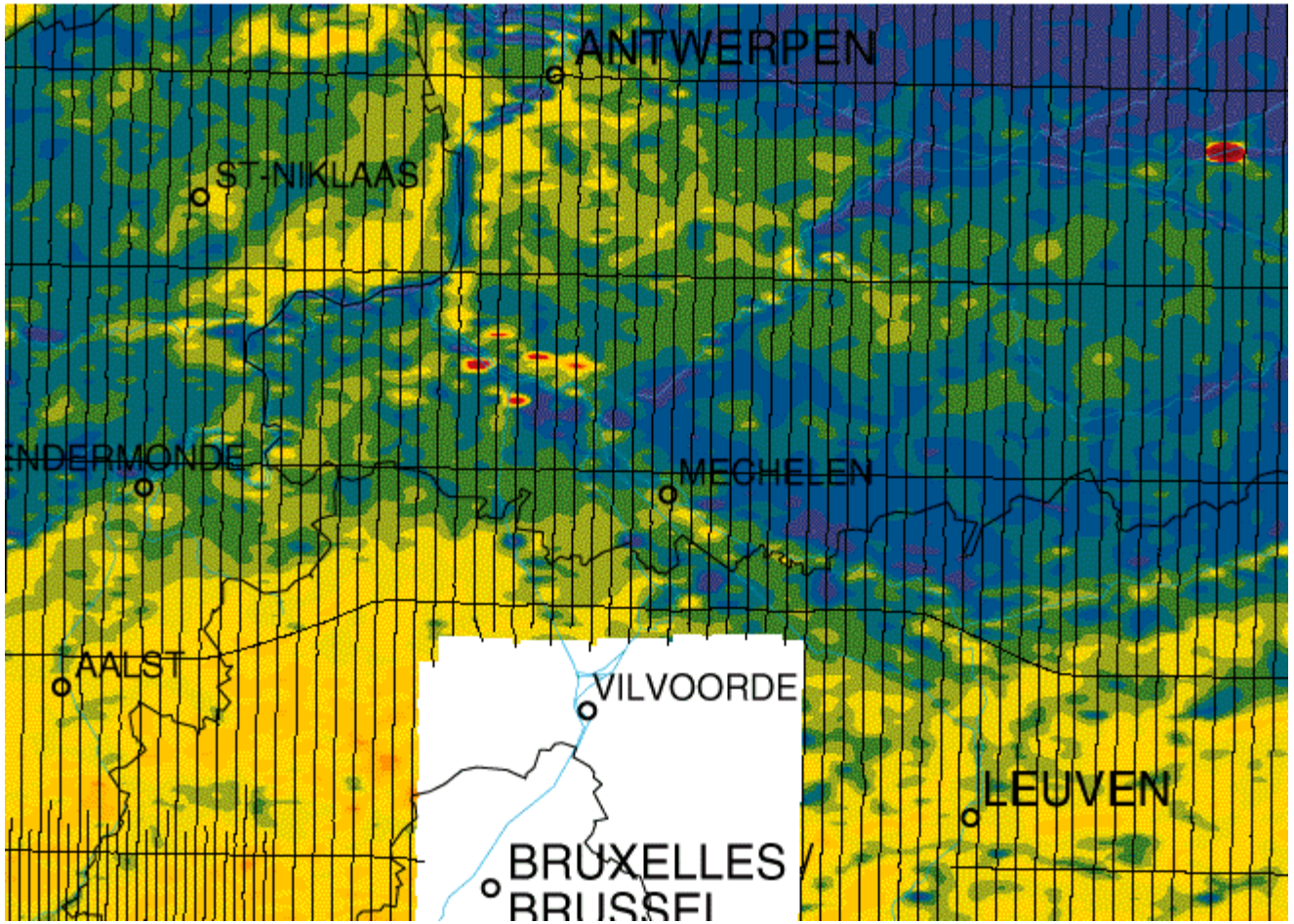
[C − 2015/00733]

30 NOVEMBER 2015. — Besluit van het Federaal Agentschap voor Nucleaire Controle houdende de vaststelling van de risicozones en de zones bedoeld in respectievelijk artikel 4 en artikel 70 van het koninklijk besluit van 20 juli 2001 houdende algemeen reglement op de bescherming van de bevolking, van de werknemers en het leefmilieu tegen het gevaar van de ioniserende stralingen

Geogenic and Antropogenic radon risk areas:
Zone for which on the basis of measurements or other data that FANC disposes of, it can be estimated that more then
5% of buildings the radon action level will be passed

Antropogenic radon risk zones

Airborne gamma-spectrometry



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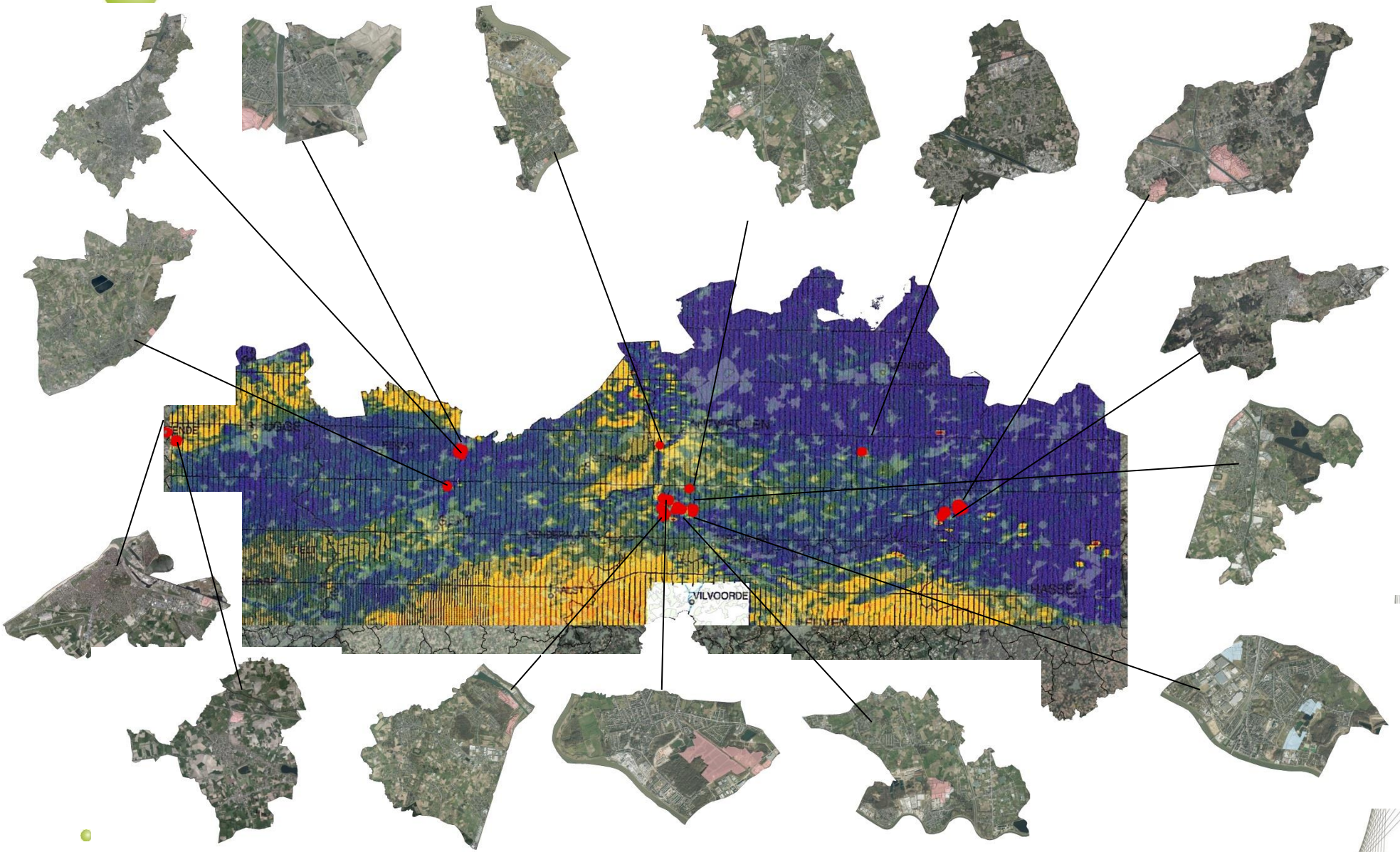
- In total 15 sites :



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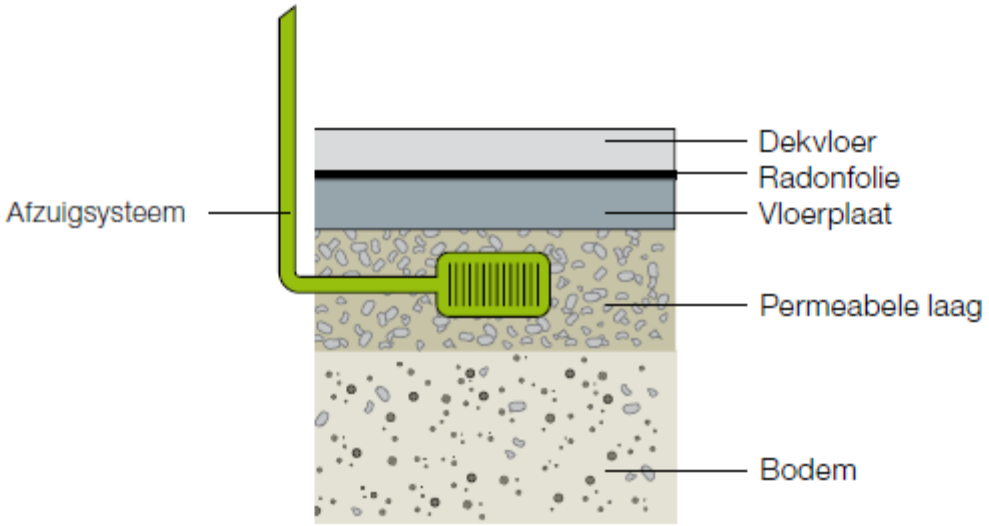
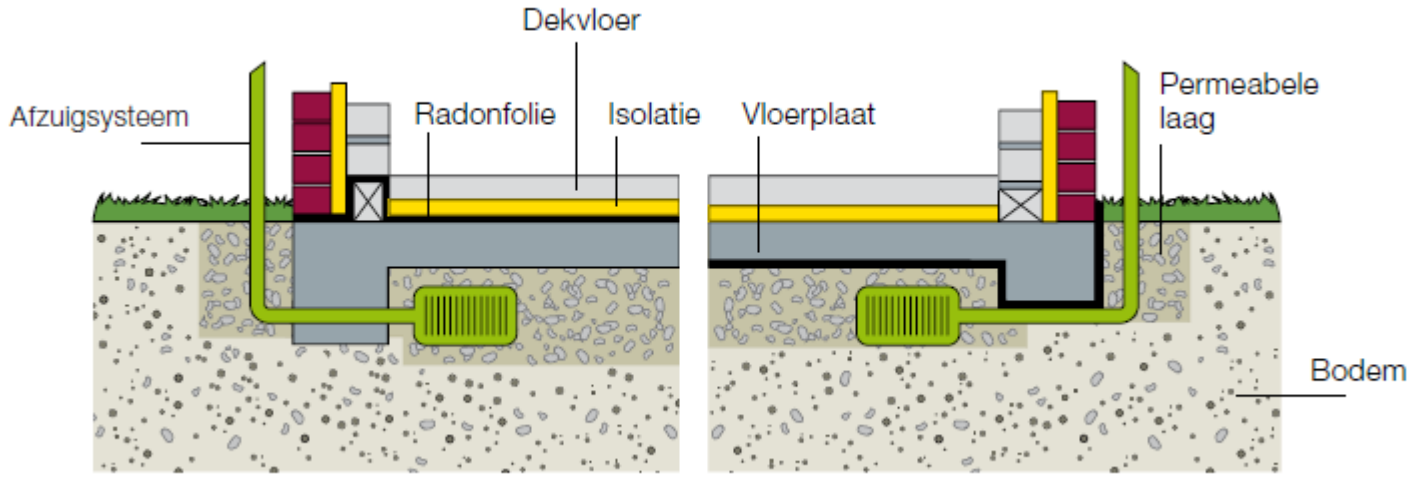
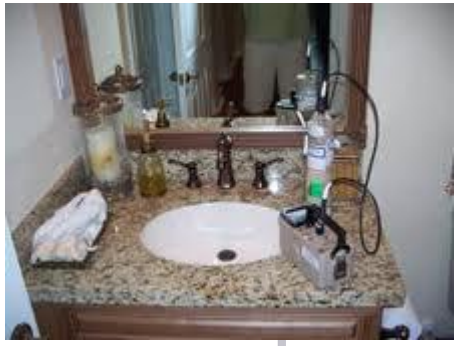

Afzuigsysteem
Dekvloer
Radonfolie
Vloerplaat
Permeabele laag
Bodem


Afzuigsysteem
Dekvloer
Radonfolie
Isolatie
Vloerplaat
Permeabele laag
Bodem


Tyvek
DUPONT


Tyvek
DUPONT

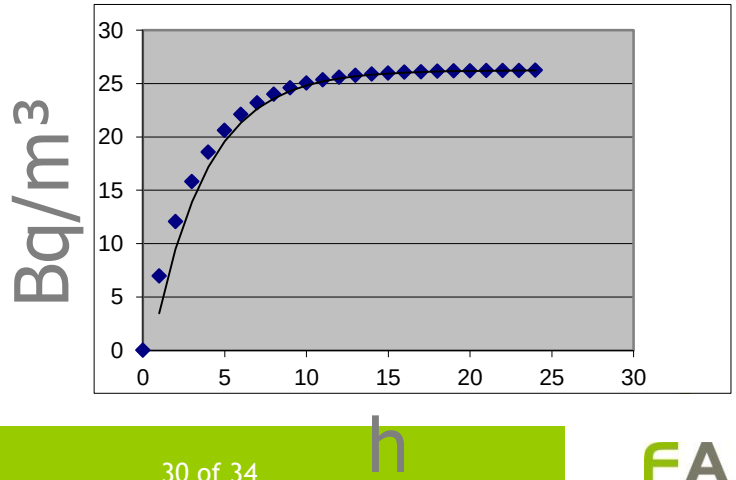
Radon in building materials



Building materials contain radionuclides (U, Ra, Th, K…en Bq/kg):

bouwmateriaal	Ra-226	Th-232	K-40
beton	20-70	05 tot 40	16-1100
baksteen	10-140	10-130	230-1200
cement	15-100	10 tot 60	50-600
gips	10-300	1 tot 300	20-800
graniet	10-160	10-350	20-2500
caramiek	20-200	30-70	300-1000

Leading to a buildup of concentration:



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Radon in low-energy buildings

Air-tightness of the building!

Natural air renewal =
Blower door 50 Pa/20 (10 to 30)

0.6/20=0.03 h^{-1} (15m^3 for 500m^3)

Blower Door test

Air changes per hour at pressure difference of 50 Pa:

n50:
~3 h^{-1} relatively airthight building

~1 h^{-1} strongly airthight building

<0.6 h^{-1} passive house

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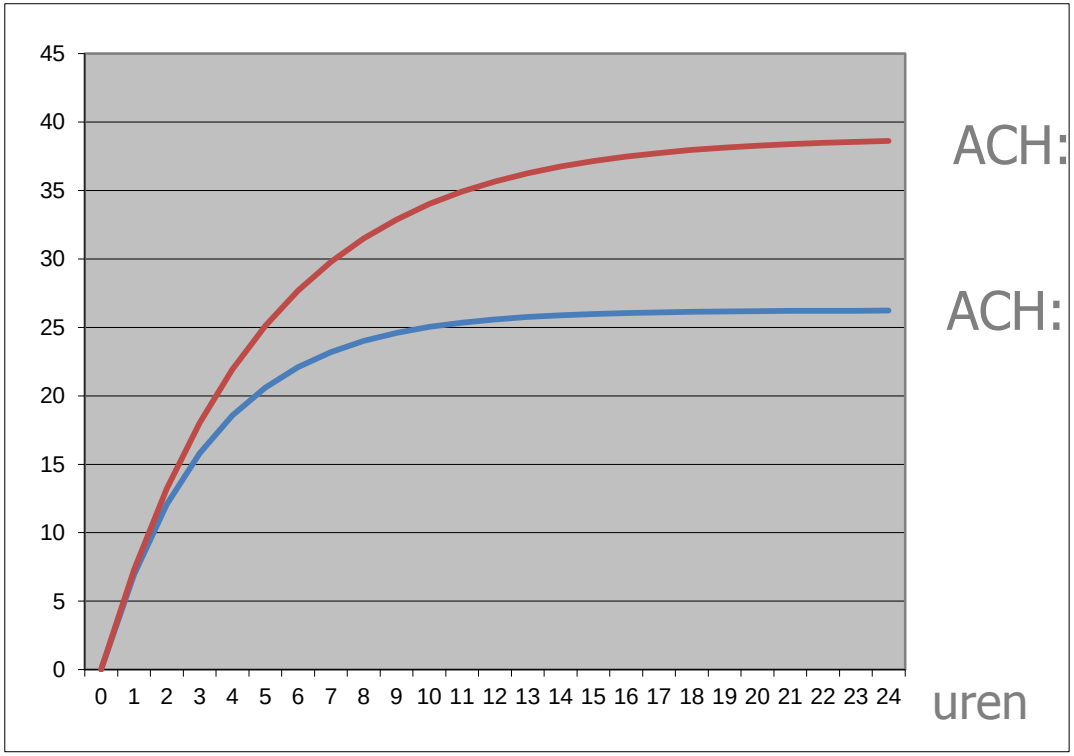
Radon in low energy buildings

Ventilation is essential:



Exhalation = 5 Bq/m²/h in a standard room

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CONCLUSIONS

- Radon affects the Belgian population and workplaces
- It has to be considered from a radiation protection point of view
- Belgian Radon Action Plan is operational tool to manage radon exposure at home and at work
- Radon in dwellings and in workplaces has to regulated following the 2013/59/euratom EU Directive
- Key issues are:

Mapping, informing, tracing, training and protecting

THANK YOU for your attention!

More info?

www.actionradon.be : testing radon at home

www.radonatwork.be : testing radon at work and declaration

FANC web site www.fanc.fgov.be, click on Radon