



Ecole d'ingénieurs et d'architectes de Fribourg
Hochschule für Technik und Architektur Freiburg

Radon and buildings energy efficiency in the French speaking part of Switzerland



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Hes·so  **FRIBOURG
FREIBURG**
Haute Ecole Spécialisée
de Suisse occidentale
Fachhochschule Westschweiz

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Atmos'Fair

Lyon, France / 24 et 25 september 2014

Main goal

- Do energy-saving measures have an impact upon indoor radon concentrations?

Premices

- Radon concentrations measurements for a large sample of new and refurbished energy-efficient single-family dwellings in French speaking part of Switzerland : over 200 Minergie dwellings and more than 450 traditional houses

Project supported by the STC-FR (Science & Technologie Center of the Canton of Fribourg) as well as Minergie, FOPH and other partners from the building construction sector

- A particular attention has been paid to the effective envelope's air tightness as well as to the ventilation system

Research team

- College of Engineering and Architecture of Fribourg (EIA-FR), attached to the University of Applied Sciences of Western Switzerland, Fribourg (FR)



Dr Corinne Hager Jörin
Statistical analysis



Jérémy Crucy
Scientific collaborator
Data basis manager



Dr Joëlle Goyette Pernot
Mesqualair team leader

Swiss energy context

- Buildings are consuming 50% of primary energy
 - 30% for heating, cooling and hot water production
 - 14% for lightning
 - 6% for construction and maintenance
- Building construction sector is responsible of more than 50% of CO₂ emissions

Proposed solutions in Switzerland

- Prescriptions

- According to the Federal Constitution (art. 89, al. 4) cantons are responsible to take and apply measures in order to reduce buildings energy consumption

- Norms

- SIA 380/1 Thermal energy in building

- Standards

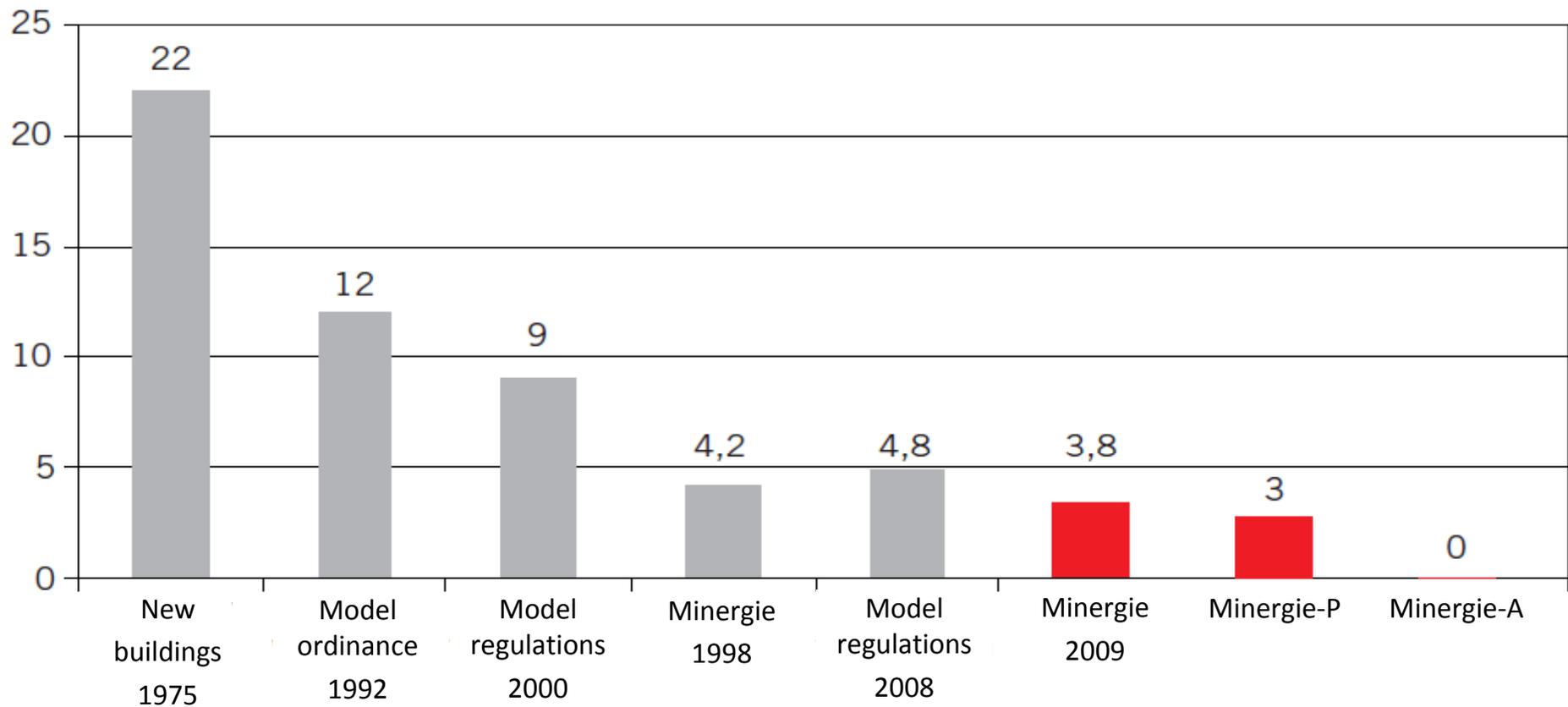
- Minergie label

- National subsidy programme

- Main goal is to reduce CO₂ emissions by 20% up to 2020 (CO₂ law) which means, for the building sector, to reduce CO₂ emissions by 2,2 millions tons

Thermal energy rating of new buildings

Heating oil equivalent – litres per m² floor area



MINERGIE®

Mehr Lebensqualität, tiefer Energieverbrauch

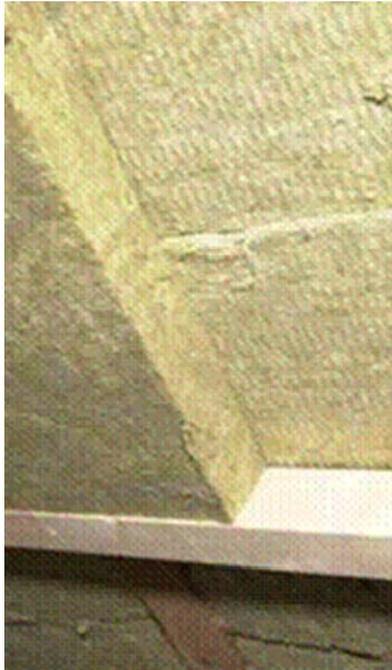
Meilleure qualité de vie, faible consommation d'énergie

- A label for new and refurbished buildings
- Mutually supported by the Swiss Confederation, the Swiss Cantons along with Trade and Industry
- Heating energy demand is calculated according to Swiss Standard SIA 380/1. Upper limit values depend on the building category, the local climate and the building form factor
- Users comfort in the building is one main goal of Minergie
- This level of comfort requires high-grade building envelope and continuous air renewal

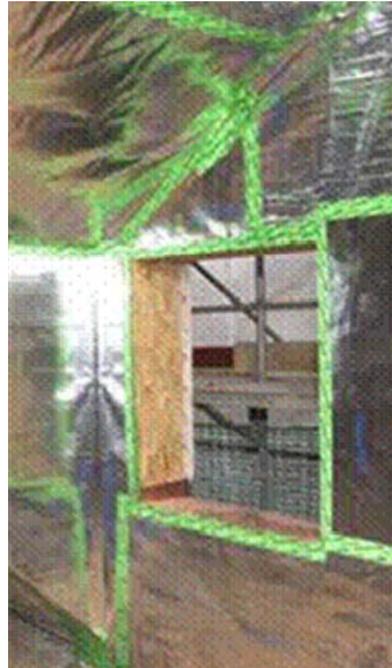
Minergie labels

- **MINERGIE[®]** general energy consumption must not exceed 90% of SIA compulsory standards
- **MINERGIE-P[®]** buildings with very low energy consumption (60% of SIA standards) equivalent to the “Passive House” European standard
- **MINERGIE-ECO[®]** ecological requirements added such as recyclability, indoor air quality, noise protection ... to the regular Minergie standards
- **MINERGIE-A[®]** “Nearly zero energy building” and requirement to cover the remaining energy needs by renewable sources exclusively

Requirements of energy efficient buildings



High grade building envelope + no thermal bridges



Air tightness

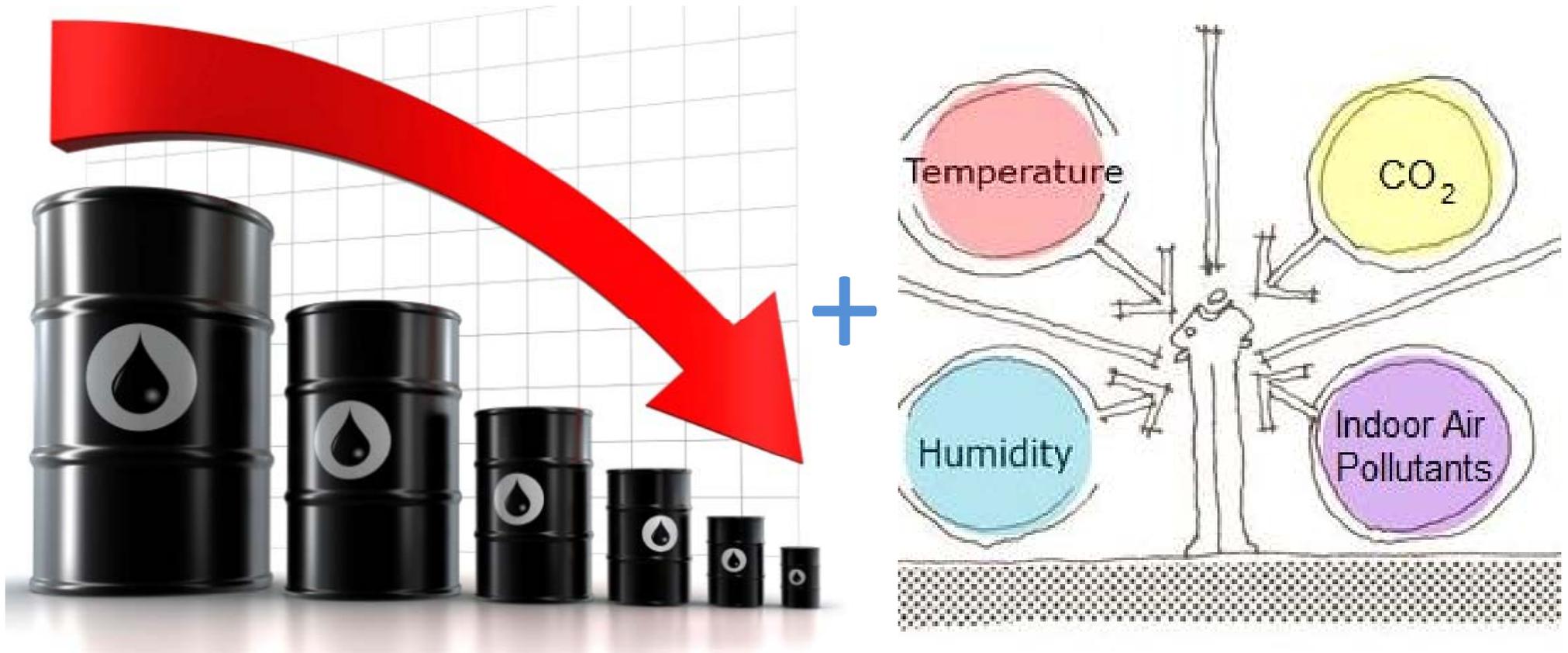


Automatic ventilation system



Protection from excessive solar heat gains in summer

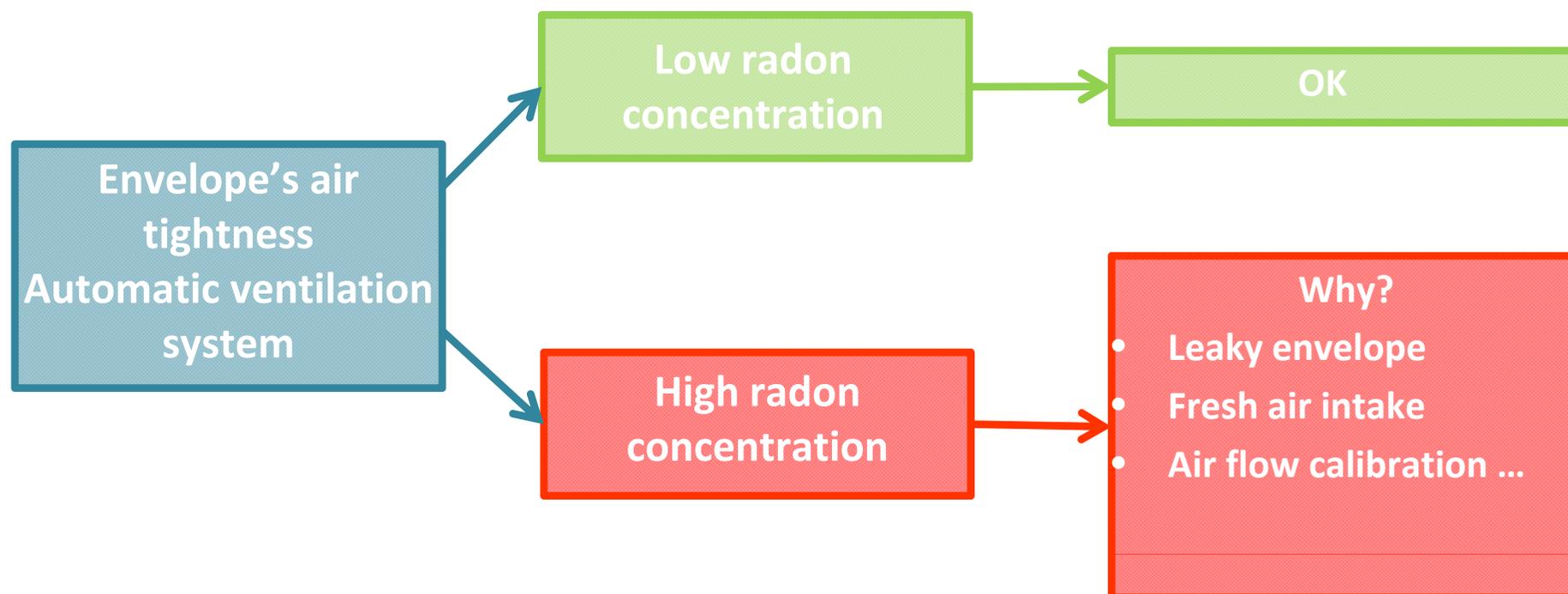
Requirements of energy efficient buildings



Research hypothesis



Indoor air quality may be altered inside efficient energy buildings (refurbished traditional ones and Minergie ones) due to specific characteristic of these
– discussed case : radon

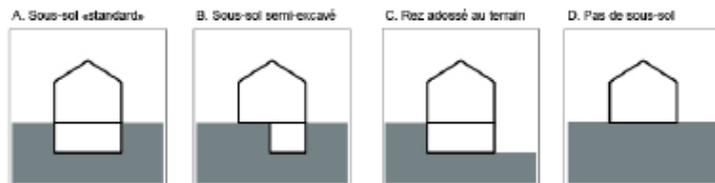


Questionnaire

20. 3.3 Selon les schémas ci-dessous, à quelle configuration correspond votre habitation?

Une seule réponse possible.

- A
- B
- C
- D
- Autre : _____



21. 3.4 Une partie du sol de votre maison est-elle en terrain naturel?

ex: cave en terrain naturel recouvert de graviers

Une seule réponse possible.

- Oui
- Non
- Je ne sais pas

22. 3.5 Combien y a-t-il de pièces habitées au sous-sol?

Une seule réponse possible.

- Aucune
- 1
- 2
- Autre : _____

23. 3.6 S'il y a des pièces au sous-sol, quelles sont leurs fonctions?

24. 3.7 Comment accédez-vous au sous-sol?

Plusieurs réponses possibles.

- Par l'extérieur
- Par l'intérieur (avec une porte de séparation)
- Par l'intérieur (sans séparation)
- Autre : _____

25. 3.8 Votre habitation est-elle équipée d'un vide sanitaire?

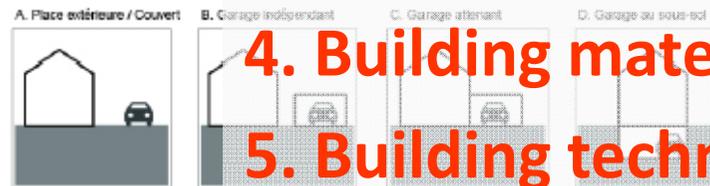
Une seule réponse possible:

- Oui
- Non
- Je ne sais pas

26. 3.9 Selon les schémas ci-dessous, où gardez-vous votre voiture?

Une seule réponse possible:

- A
- B
- C
- D
- Autre : _____



27. 3.10 Si vous avez répondu par oui, comment accédez-vous au garage?

Une seule réponse possible:

- par l'extérieur
- par une porte donnant dans un espace de vie (salon, séjour, cuisine, etc)
- par une porte donnant dans un espace dédié (entrée, bureau, chambre, buanderie, etc)
- Autre : _____

28. 3.11 Quel type d'escaliers trouvez-vous dans votre habitation?

Une seule réponse possible:

- Une cage d'escalier (fermée aux étages par des portes palières)
- Des escaliers ouverts (sans portes palières ou sans porte palières)
- Des escaliers semi-ouverts (sous-sol séparé par une porte palière, les autres étages ouverts)

4. Matériaux

29. 4.1 De quelle nature est la structure du bâtiment?

Une seule réponse possible:

- Maçonnerie (béton, brique)
- Bois
- Mixte
- Autre : _____

0. Personal identification

1. Construction consideration

2. Inhabitants description

3. Organisation in the house

4. Building materials

5. Building technique

6. Equipment and use

7. Damages

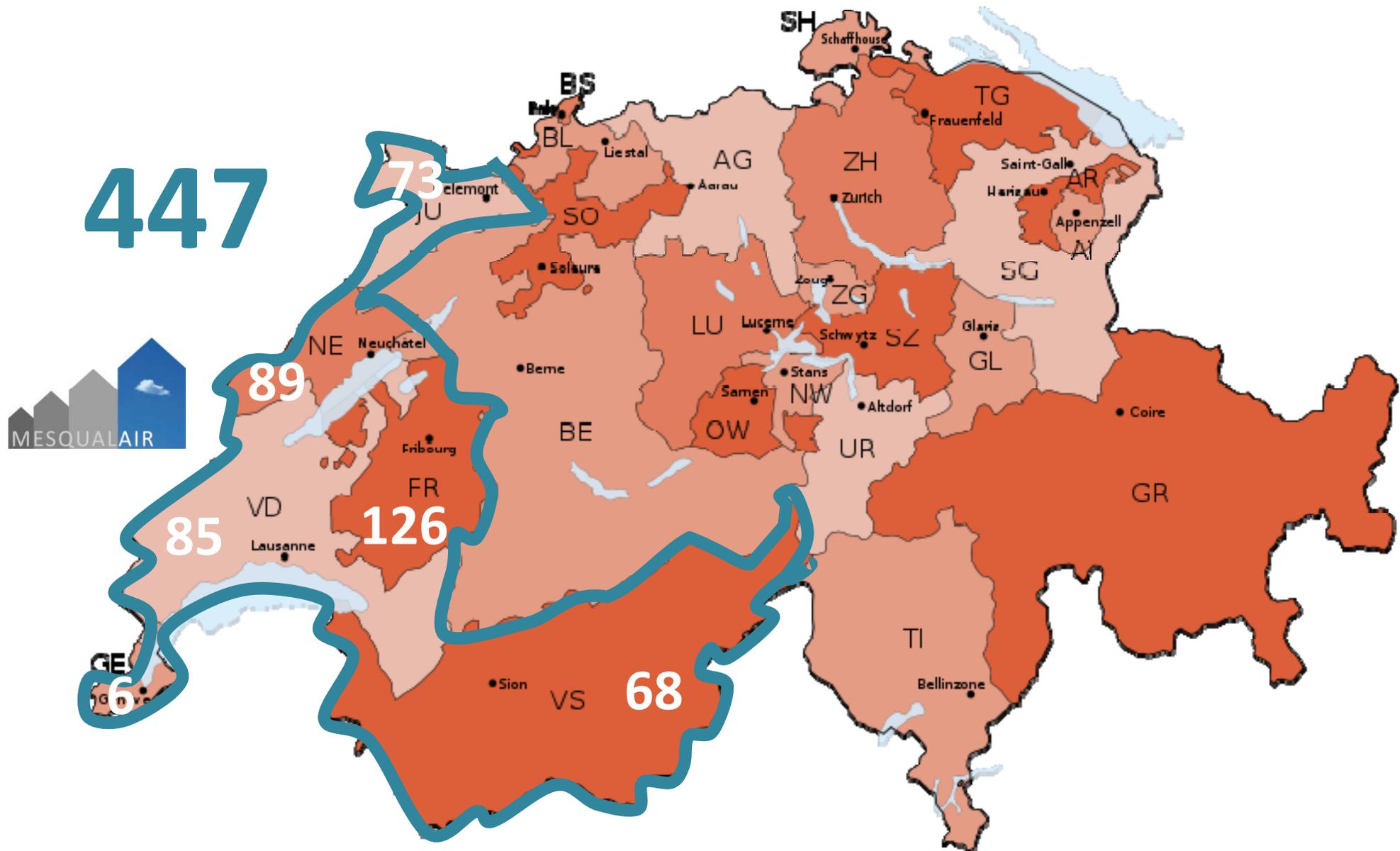
8. Life customs

9. Comfort

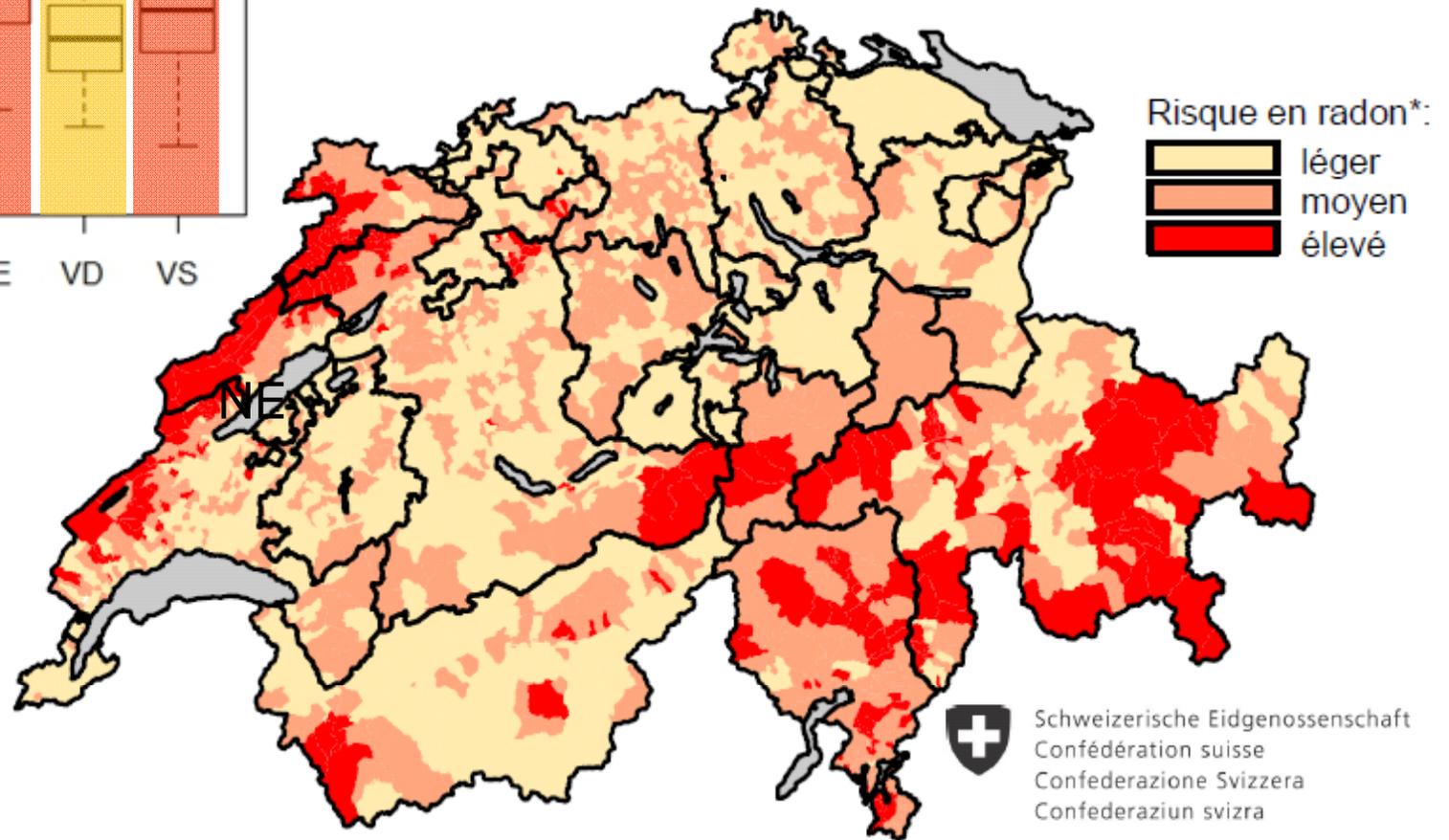
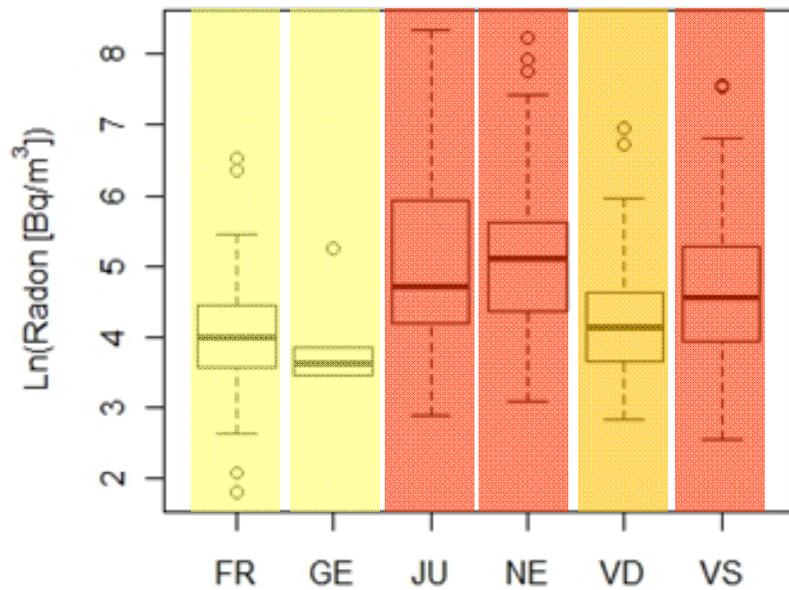
10. Health

11. Energy consumption

Distribution of the buildings included in the projects



Indoor radon concentration versus radon risk



Preliminary results

Département fédéral de l'intérieur DFI
Office fédéral de la santé publique OFSP

Etat: 2013
Source : SwissBoundaries2012©Swisstopo

Cadre réglementaire helvétique

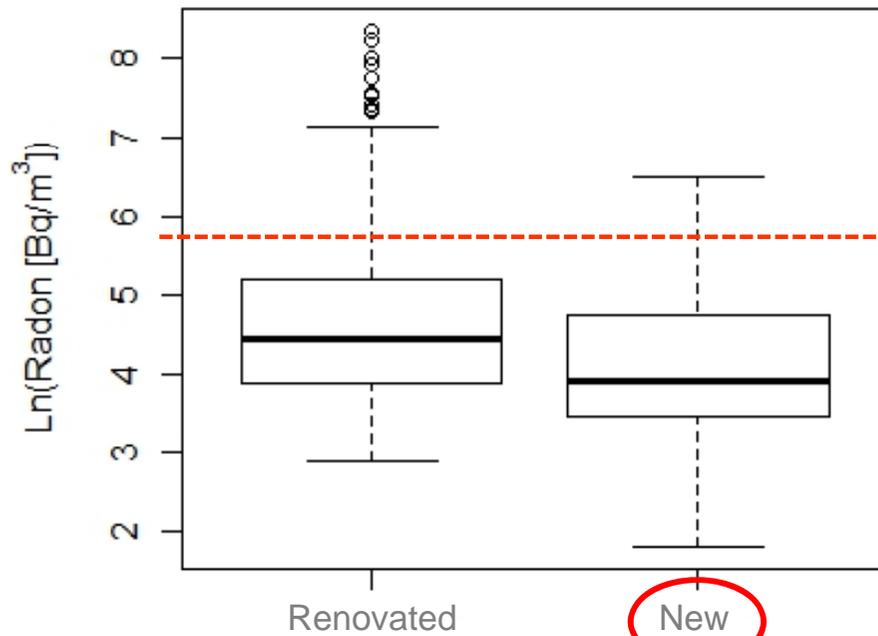
Ordonnance de 1994 sur la radioprotection (Art 110)

| | Suisse | Union européenne | OMS (fin 2008) |
|--|--|--|--|
| Locaux habités Aussi les écoles! Pas les caves! | Valeurs légales: Bâtiments existants: 1000 Bq/m³ (valeur limite) Bâtiments assainis et nouveaux bâtiments : 400 Bq/m³ (valeur directrice) | Recommandation: Bâtiments existants: 400 Bq/m³ (valeur de référence) Nouveau bâtiments: 200 Bq/m³ (val. de planification) | Recommandation: Bâtiments existants: 100-400 Bq/m³ (valeurs recommandées selon les situations nationales) |
| Places de travail | Valeur légale 3000 Bq/m³ (valeur limite) | | |

Recommandation depuis 2010: 300 Bq/m³ pour les locaux habités

Do rehabilitation affect the indoor radon concentration?

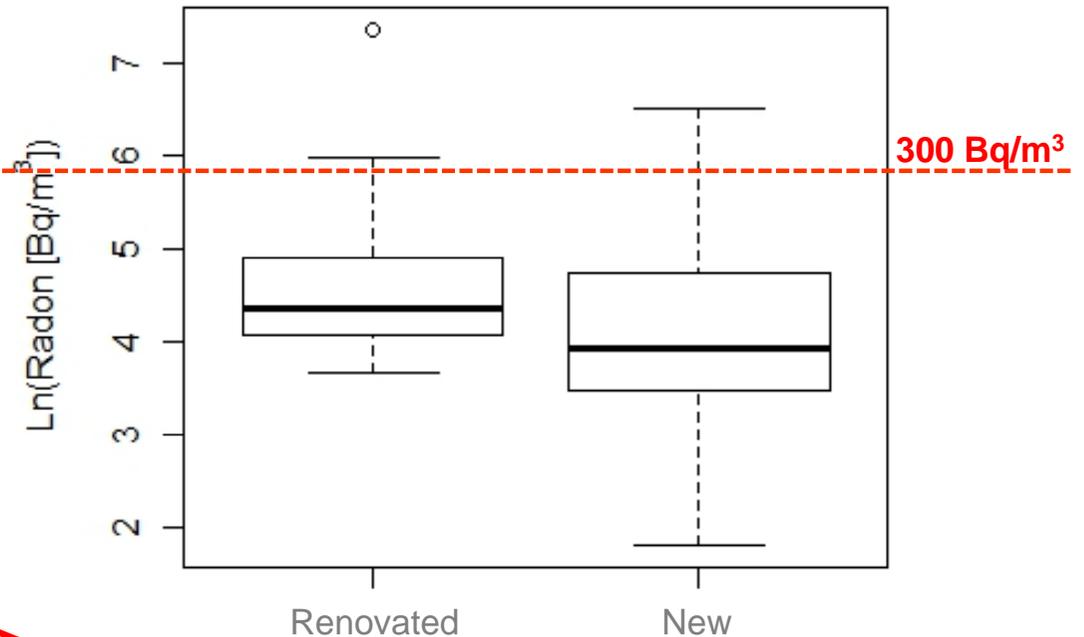
Average 231 Bq/m³ 105 Bq/m³



All buildings

Radon concentrations are significantly higher in traditional buildings ($p < 0.01$)

Building typology does not influence radon concentration
However the refurbished Minergie sample is very small (19/120)

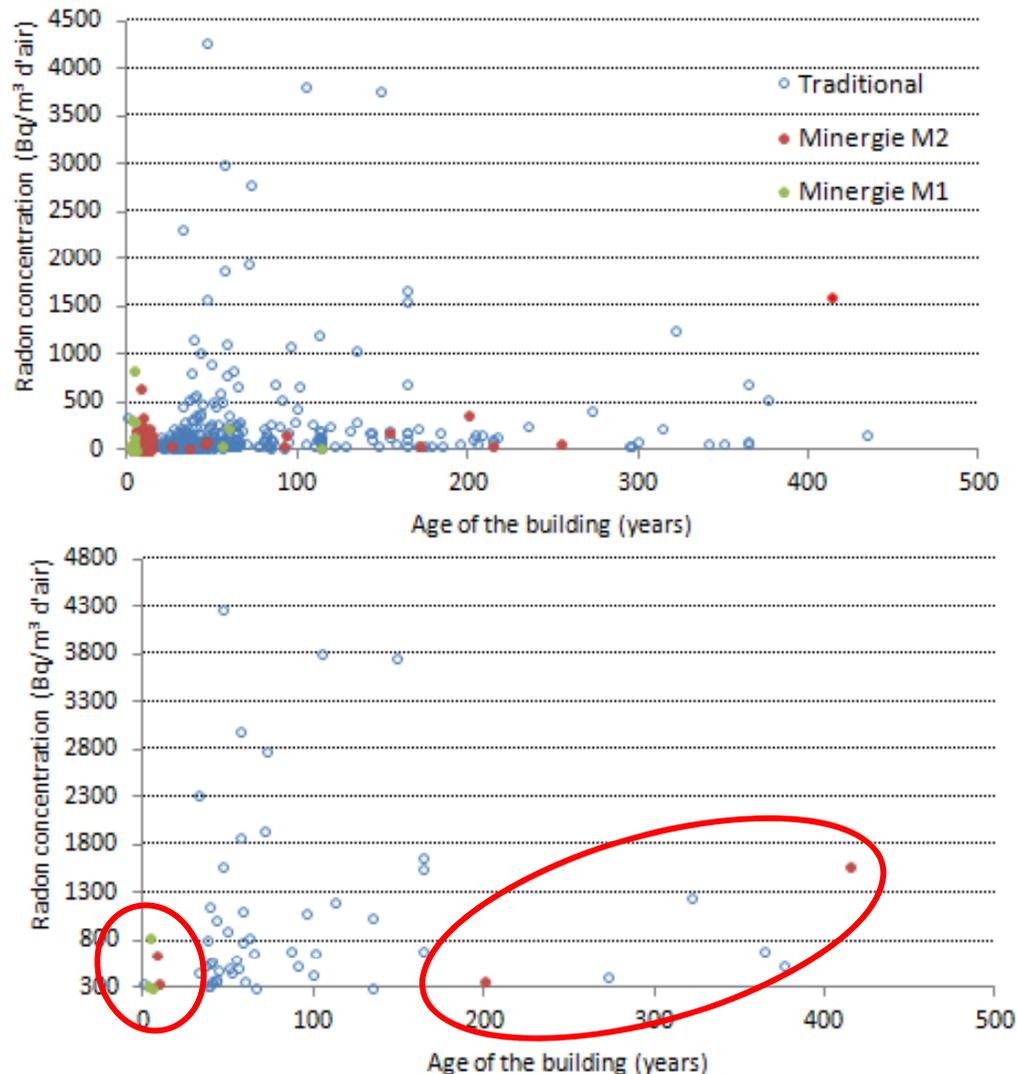


Minergie dwellings

YES

Preliminary results

Radon concentration according to buildings' age in Romandie



- No specific tendency between building's age and indoor radon concentration
- Even so, older buildings are not the worst!
- 353 traditional dwellings (blue) and 120 Minergie buildings (red and green)
- Only 5% (7) of the Minergie buildings exceed 300 Bq/m³. Among them, two are rehabilitations and 5 are new ones
- Among the traditional ones 15.6% (55) exceed 300 Bq/m³. All are energy refurbished houses

Preliminary results

Radon vs Minergie (indoor quality)

Are radon indoor condition better in Minergie dwellings than in traditional ones?

Radon concentration tend to increase inside buildings with insufficient air exchange

Minergie buildings generally imply a stronger air tightness

Minergie standards require an automatic ventilation system

Radon concentration inside Minergie buildings **should** be very low

Some characteristics of these problematic buildings ...

| Canton | Radon | Age | Ventilation | Control mode | Frequency of use | Type | Frequency of filter change | Living space DS | Natural soil |
|----------|-------|-----|-------------|--------------------------|------------------|------------------------------------|----------------------------|-----------------|--------------|
| VS 1 | 319 | New | Yes | Manual | | Double flow with recycling of heat | | Yes | No |
| VS 1 (P) | 849 | New | Yes | CO ₂ detector | | Double flow with recycling of heat | | No | No |
| VD 1 | 344 | New | Yes | Prog | | Double flow with recycling of heat | | Yes | Yes |
| VS 2 | 352 | New | Yes | Prog | Always | Double flow with recycling of heat | Yes every 6 months | Yes | Yes |
| VS 2 | 666 | New | Yes | Prog | Always | Double flow with recycling of heat | Yes every 6 months | No | Yes |
| NE 2 | 1594 | R | Yes | Manual | Rarely | Double flow with recycling of heat | Never | Yes | Yes |
| VD 2 | 393 | R | Yes | Manual | Always | Double flow with recycling of heat | Yes every 6 months | No | Yes |

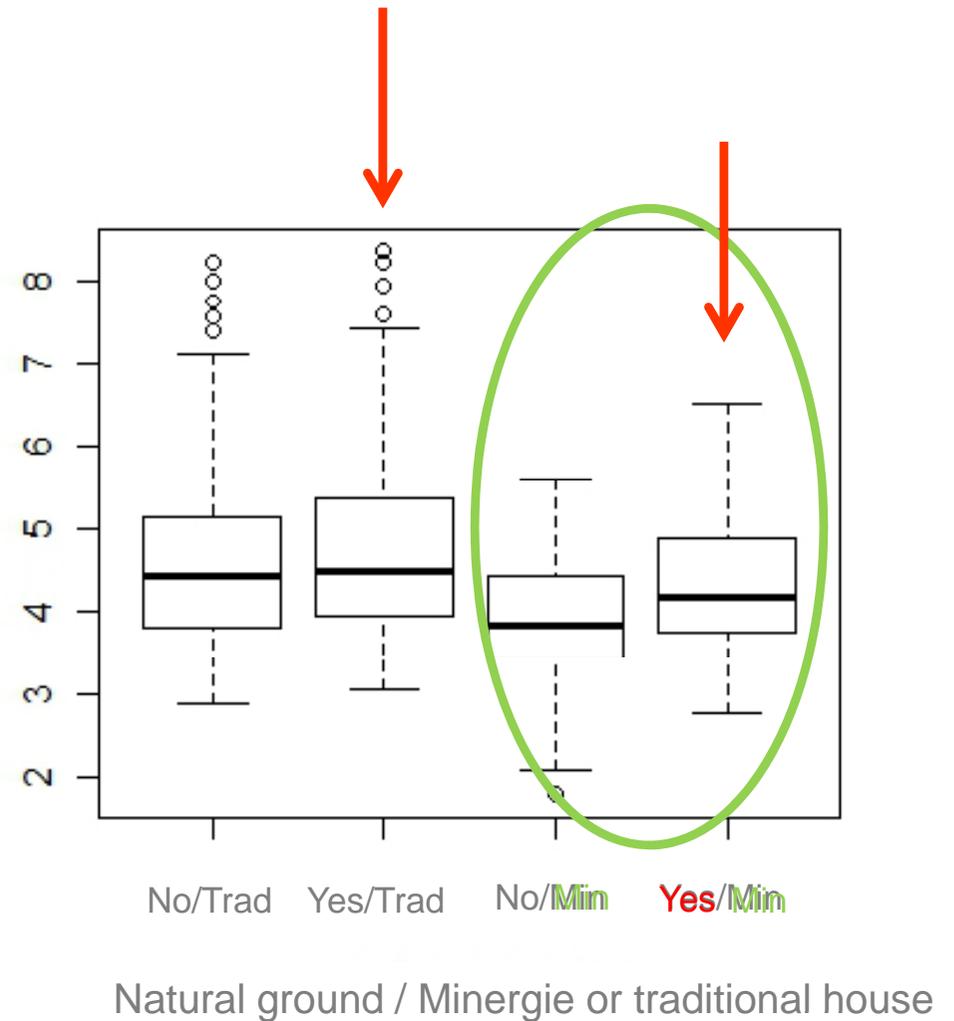
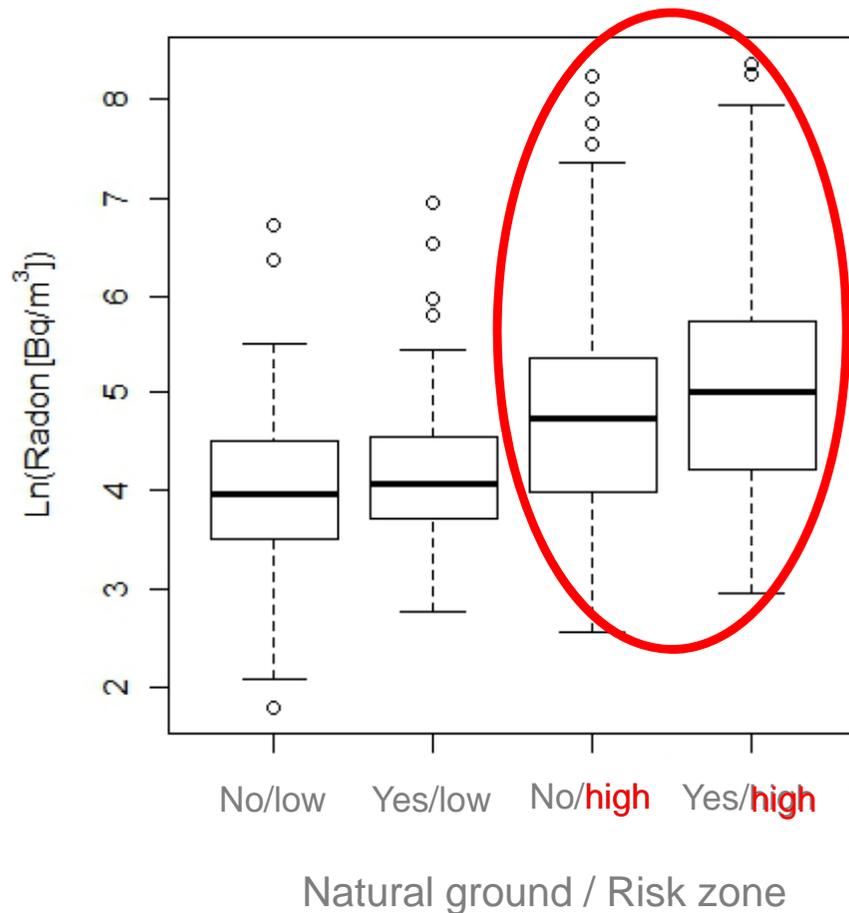
Questions

Building's age, type of label, ventilation control mode, maintenance, construction choices?

Responsibility? ...

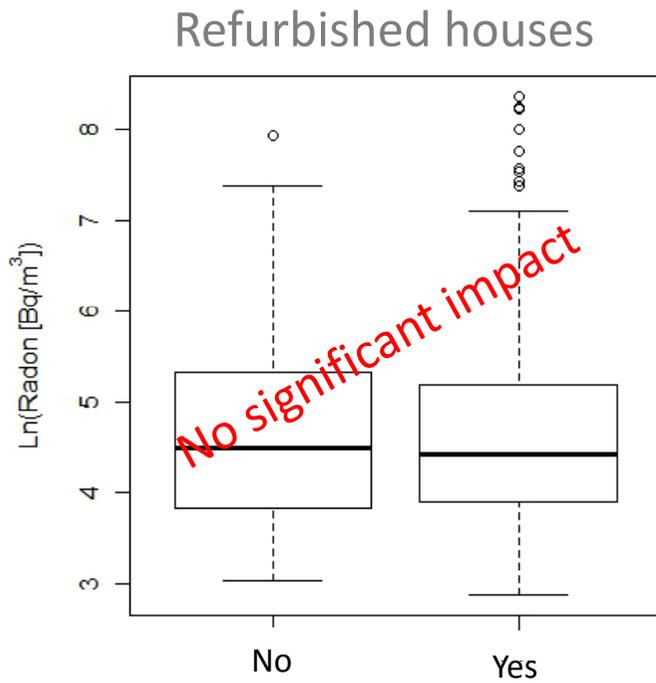
Preliminary results

Impact of the contact with natural ground according to the radon risk zone



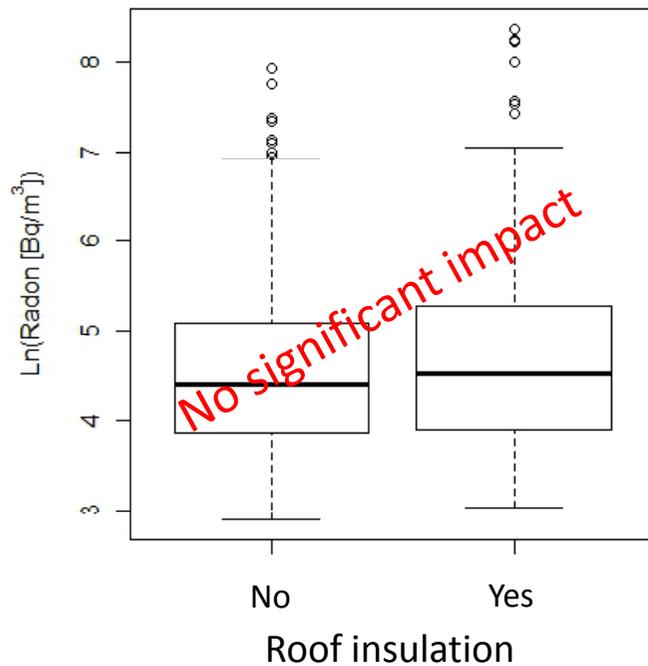
Preliminary results

Impact of the type of energy retrofitting



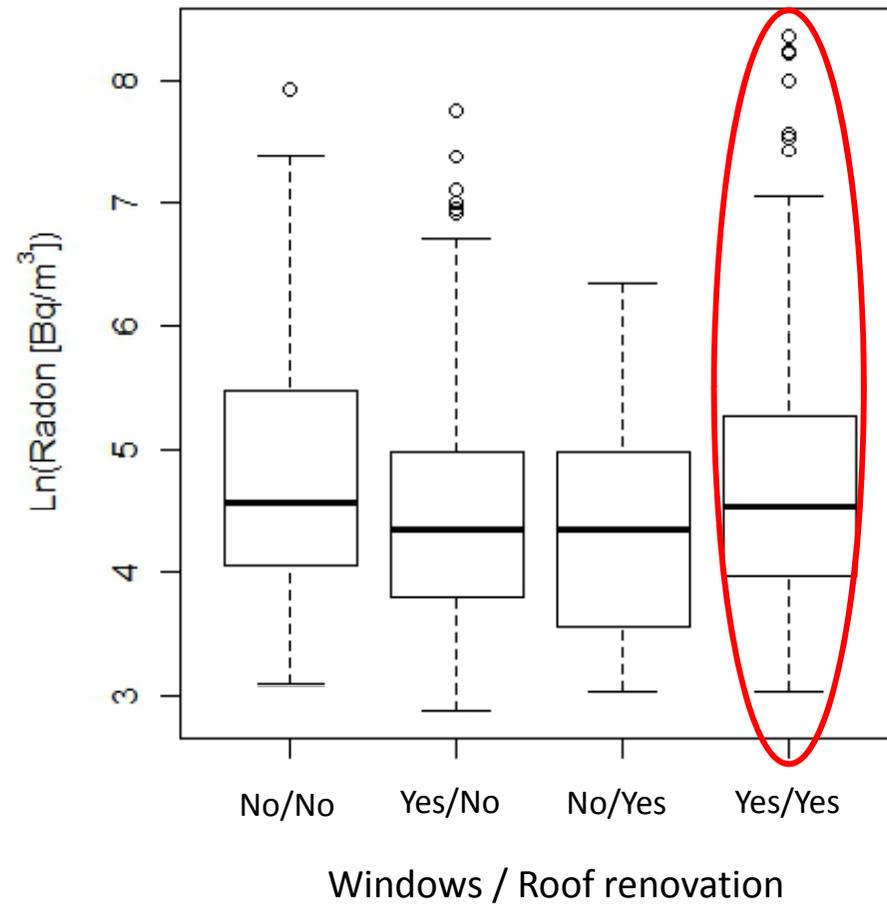
Windows replacement

Refurbished houses



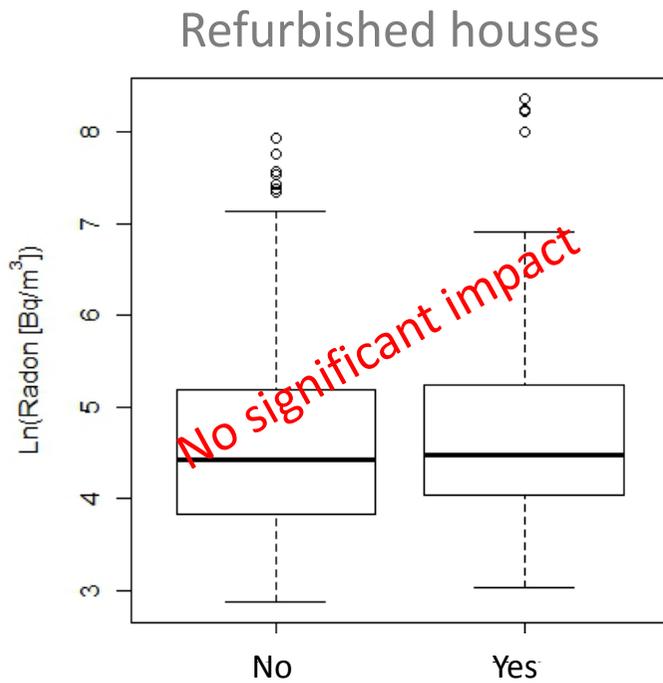
Refurbished houses

Light effect?

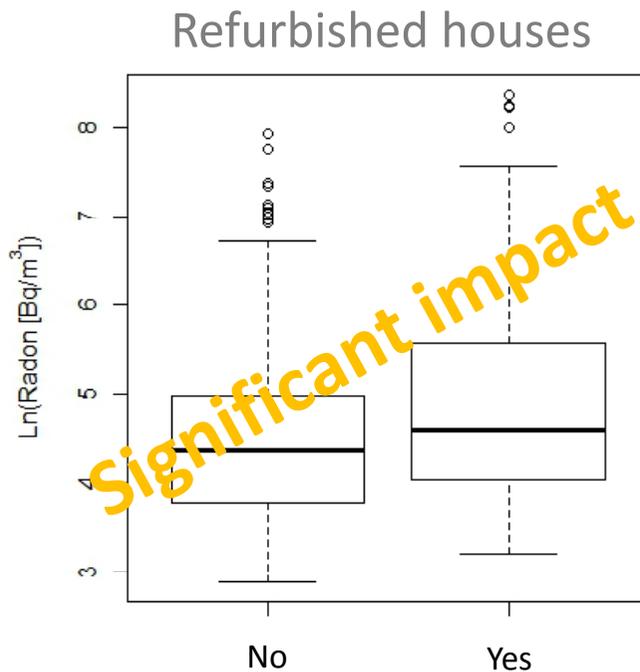


Preliminary results

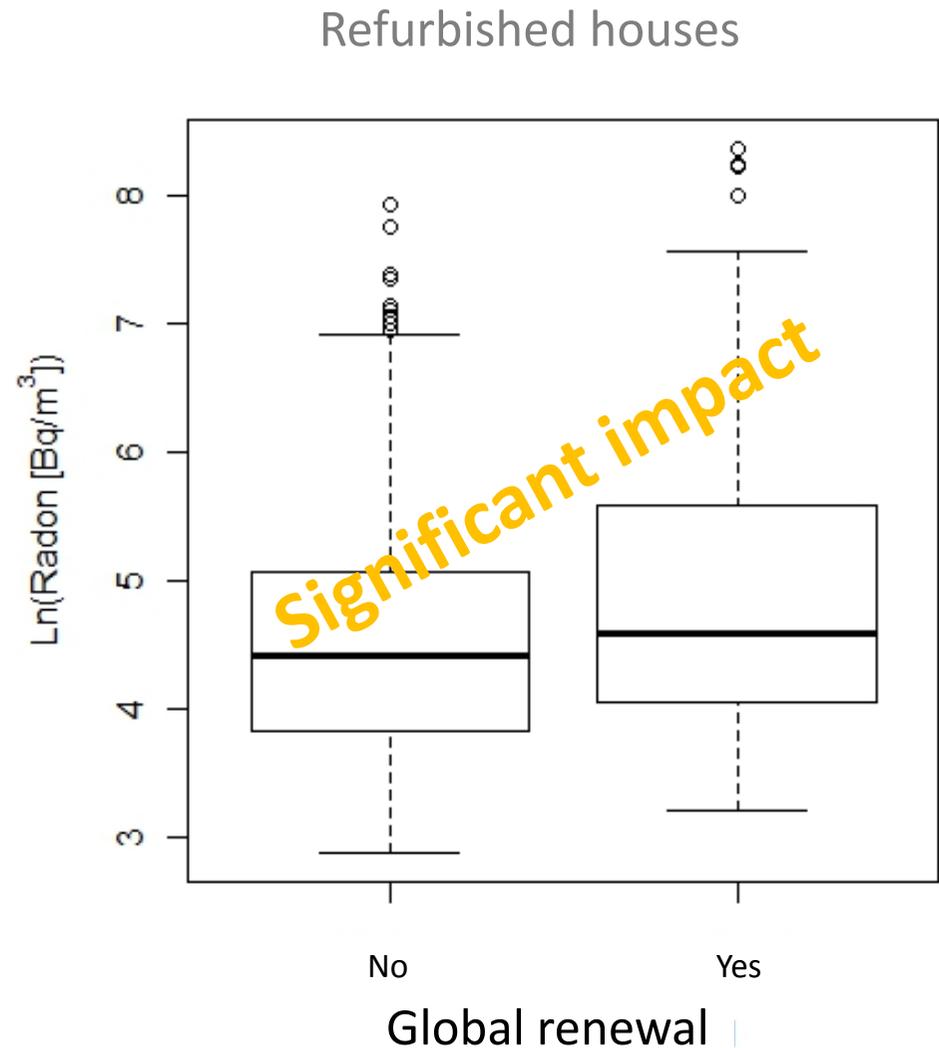
Impact of the type of energy retrofitting



Inside surfaces renewal

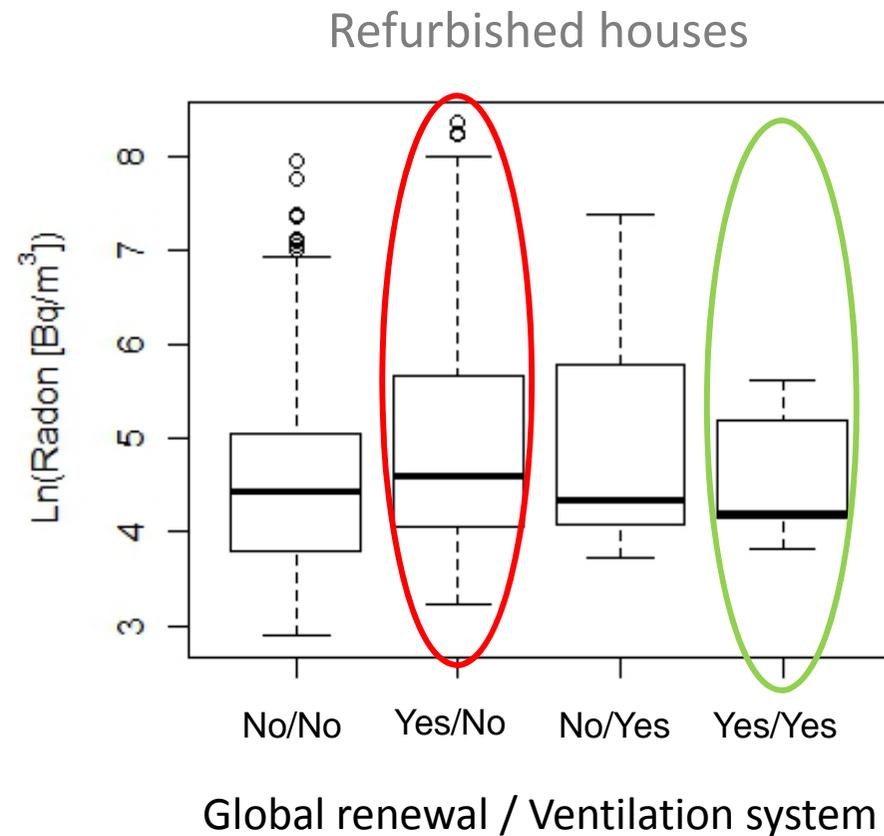
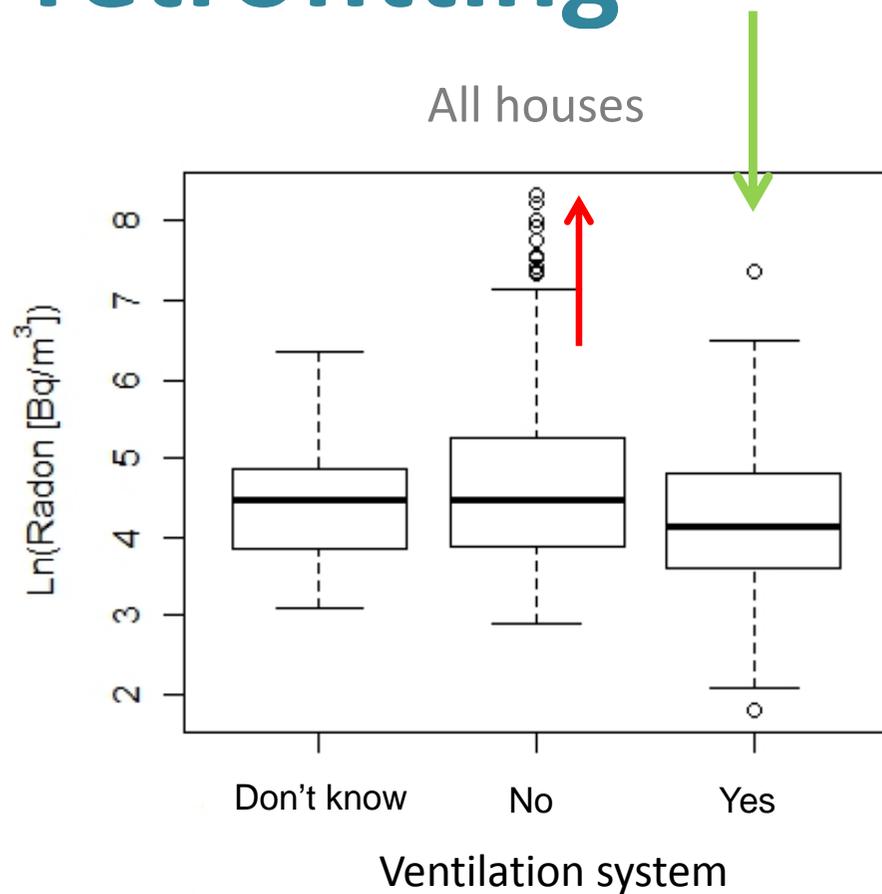


Outdoor walls renewal



Preliminary results

Installation of a ventilation system combined with global energy retrofitting



Preliminary results

Concluding remarks

1 – Impact of energy retrofitting

- Energy retrofitting measures affect indoor radon concentration
- Radon concentrations are significantly lower in Minergie[®] buildings than in traditional ones
- However some Minergie dwellings do show high concentrations

Concluding remarks

1 – Impact of energy retrofitting

- Individual actions like, windows replacement, roof as well as cold inside surfaces insulation do not impact specifically indoor radon concentration
- But a light tendency to enhancement of indoor radon may be noticed when these actions are combined together especially when the envelope of the building is refurbished

Concluding remarks

2 – Local conditions impact

- Looking inside energy saving dwellings, geology may be a real source of troubles in some region of high risk level of radon if :
 - there is natural ground in the cellar
 - the indoor air renewal is not sufficient

Concluding remarks

3 – Technical installations

- It is great to have a ventilation system installed but it is better to use it to insure good air renewal!
- A lack of maintenance can be problematic
- Way of controlling the air flow should be adjusted and checked on a regular basis

Concluding remarks

4 – Human factor impact

- People living in energy saving buildings need to be well informed about the risks and about “what to do and not to do”
- Behaviour and way of living can impact indoor air quality by negligence and/or ignorance

Key points

1. Energy renovation of the Swiss building stock is a great challenge for the close future. It represents 1.64 millions of buildings of which 83% for housing. Only 0.9% of it has been energy refurbished
2. Preliminary results of this both study open a wide field of expertise that should ultimately enable to develop recommendations to the building and energy professional sectors
3. Studying the impact of energy retrofitting measures over indoor radon and in general indoor air quality, implies to cross lots of buildings parameters as well as human factors
4. It is crucial to enhance the building professional training in order to integer these new conditions represented by energy retrofitting measures in buildings and on public health

Research still in progress ...



<http://www.pst-fr.ch/lesprojets/clusterenergiebatiment/mesqualair/>

2013-2015



Thank you for your attention



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