WHO Handbook on Indoor Radon: A Public Health Perspective

Practical Implications for Healthy Homes Professionals

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Overview

- This presentation focuses on the World Health Organization's (WHO) guidance to the global community on indoor radon and the science and deliberation around WHO's recommendations
  - The guidance was developed through over four years of dialogue and consensus of more than 100 scientists and experts from more than 30 countries

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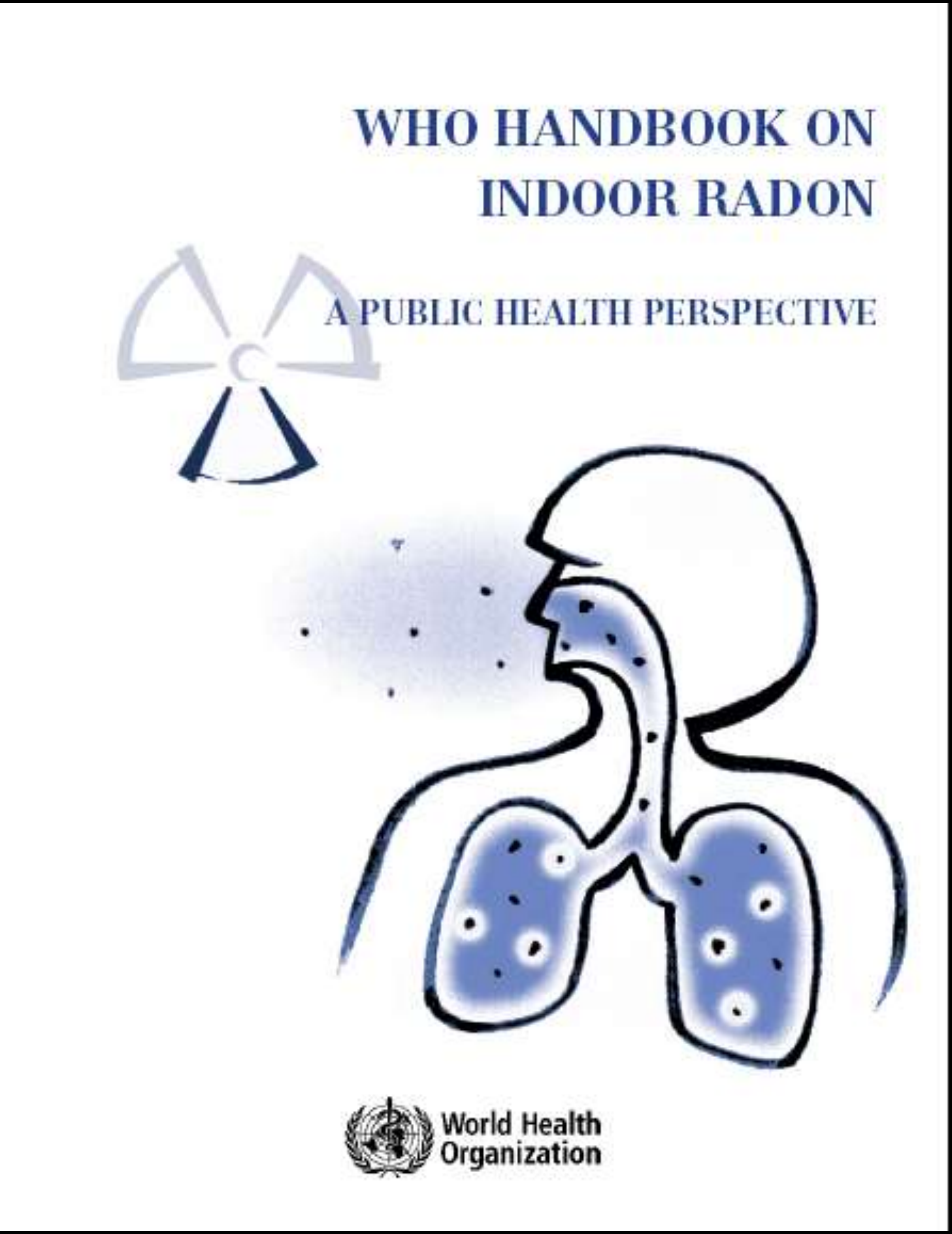

Handbook Contents

Editors

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Introduction

- Acknowledgements
  - Contributors/participants (listed in next slide)
  - Working Group Chairs (listed in a forthcoming slide)
    - And other members of the editorial group
  - Representatives from
    - International Atomic Energy Agency
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    - European Commission
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    - UK Department of Health
    - Radiological Protection Institute of Ireland

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Contributors/Participants

More than 100 scientists and radon experts from more than 30 countries

- Argentina
- Austria
- Belgium
- Brazil
- Bulgaria
- Canada
- China
- Czech Republic
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Japan
- Republic of Korea
- Lithuania
- Luxembourg
- Poland
- Romania
- Russia Federation
- Serbia
- Spain
- Sweden
- Switzerland
- United Kingdom
- United States

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- Exposure guidelines
  - David Fenton, Irish Radiation Protection Agency and Francesco Bochicchio, Italian Institute of Health
- Cost-effectiveness
  - Alastair Gray, Oxford University, and Terje Strand, Norwegian Radiation Protection Agency
- Measurement
  - R. William Field, University of Iowa
- Prevention and mitigation
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- Risk communication
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Preface

- Radon is second cause of lung cancer in the general population
  - Epidemiological studies provide convincing evidence of an association between indoor radon exposure and lung cancer
    - Even at relatively low concentrations found in residential buildings
- WHO first drew attention to the health effects of residential radon exposure in 1979
- Radon was first classified as a human carcinogen in 1988
  - By the WHO's International Agency for Research on Cancer
- In 1993, the WHO International Workshop on Indoor Radon
  - Scientists from Europe, North America and Asia proposed
    - A unified approach to control of radon exposures
    - Communication of radon health risks
- In 2005, WHO established the International Radon Project

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1. Health Effects

– Current estimates of the proportion of lung cancers attributed to residential radon range from 3 to 14%
  - Depending upon the average radon in the specific country and
  - The calculation method

  Note, there is other evidence that residential indoor radon may be responsible for 20% of lung cancers

– Lung cancer risk increases proportionately with exposure
  - **As many people are exposed to low and moderate radon concentrations, . . . *the majority of lung cancers are caused by these exposures rather than high concentrations***

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Residential Case-Control Studies

- More than 40 residential radon-lung cancer case-control studies have been completed
  - Individually, these studies are generally not definitive
    - The correlation of radon exposure and lung cancer differs considerably from one study to another
      - In part because differing
        - » Methodologies assessing smoking-related risks and
        - » Quantification of radon exposure histories
    - Therefore, pooled analysis of individual case-control studies has been made
      - 13 European case-control studies analyzed by Darby *et al.* (2005, 2006)
      - 7 North American case-control studies analyzed by Krewski *et al*. (2005, 2006)
      - 2 Chinese case-control studies analyzed by Lubin *et al.* (2004)

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International Pooling Analysis of Residential Case-Control Studies

	Number of Studies	Number of Lung Cancers	Number of Controls	Exposure Window (Years)	Increase in Lung Cancer Risk per 100 Bq/m^3 Radon Increase	
					Based on Rn Measured	Based on Long-Term Average Rn
European	13	7,418	14,208	5-35	8%	16%
North American	7	3,662	4,966	5-30	11%	---
Chinese	2	1,050	1,995	5-30	13%	
Weighted Average					10%	~ 20%

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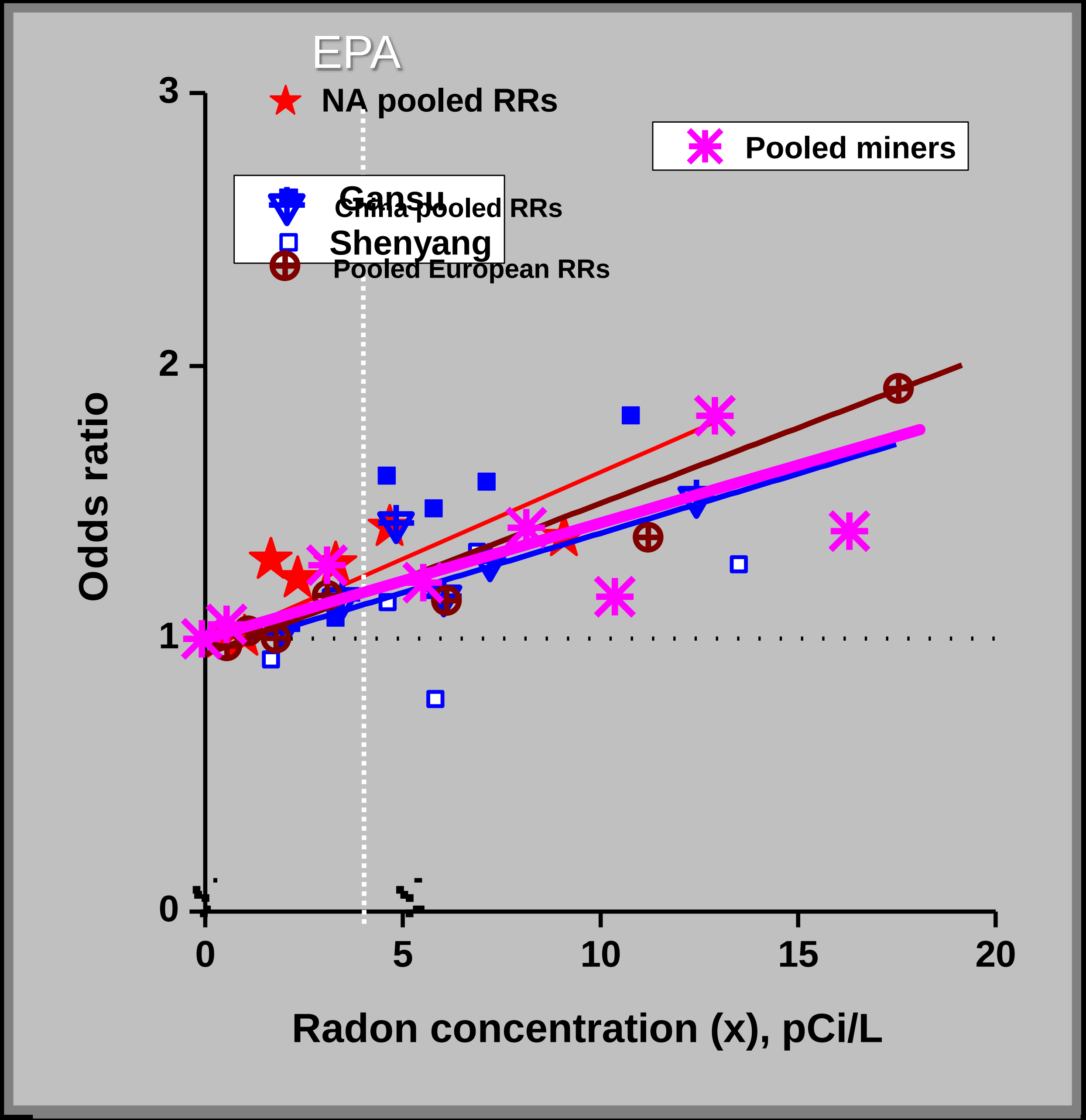
Results of Major Radon Studies of Lung Cancer



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Radon and Diseases Other than Lung Cancer

- Evidence for radon-related **mortality from cancers other than lung cancer** has been analyzed from the miner studies and strong evidence has not been found
  - Further investigations are focusing on the incidence of **leukemia**, lymphoma and multiple myeloma
    - A Czech miner study has found a positive association between radon exposure and leukemia
  - A number of other miner studies have examined the relationship between radon and **cardiovascular disease** but have not found evidence radon is causing heart disease
- About 20 ecological studies of radon exposure in the general population and **leukemia** and some have found associations
  - Not confirmed through a high quality case-control or cohort study
- A Norwegian ecological study showed an association between indoor radon and **multiple sclerosis**
  - Not confirmed through a high quality case-control or cohort study

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Risk Assessment Summary

- Large and recent studies confirm radon in homes increases lung cancer risks
  - Confirm previous studies of miners exposed to radon
- Up to 18% of lung cancers can be attributed to indoor radon
  - Other health effects have not consistently been found
  - Radon is the second leading cause of lung cancer after smoking
- There is no known threshold concentration below which radon is safe
- The majority of lung cancers caused by radon is attributed to low dose exposures of the population

(Important ~ cost-effectiveness of risk reduction strategies)

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Indoor Rn Concentrations in OECD Countries

(Organization of Economic Cooperation and Development; Bq/m^3)

	Mean	Median
Australia	11	8
Austria	99	15
Belgium	48	38
Canada	28	11
Czech Republic	***140***	***44***
Denmark	59	39
Finland	***120***	***84***
France	***89***	***53***
Germany	49	39
Greece	55	44
Hungary	***82***	***62***
Iceland	10	
Ireland	***89***	***57***
Italy	***70***	***52***
Japan	16	13
Luxembourg	***110***	***70***
Mexico	***140***	***90***
Netherland	23	18
New Zealand	22	20
Norway	***89***	***40***
Poland	49	31
Portugal	***62***	***45***
Republic of Korea	53	43
Slovakia	***87***	
Spain	***90***	***46***
Sweden	***108***	***56***
Switzerland	***78***	***53***
United Kingdom	20	14
United States	**46**	**25**
World Average	**39**	

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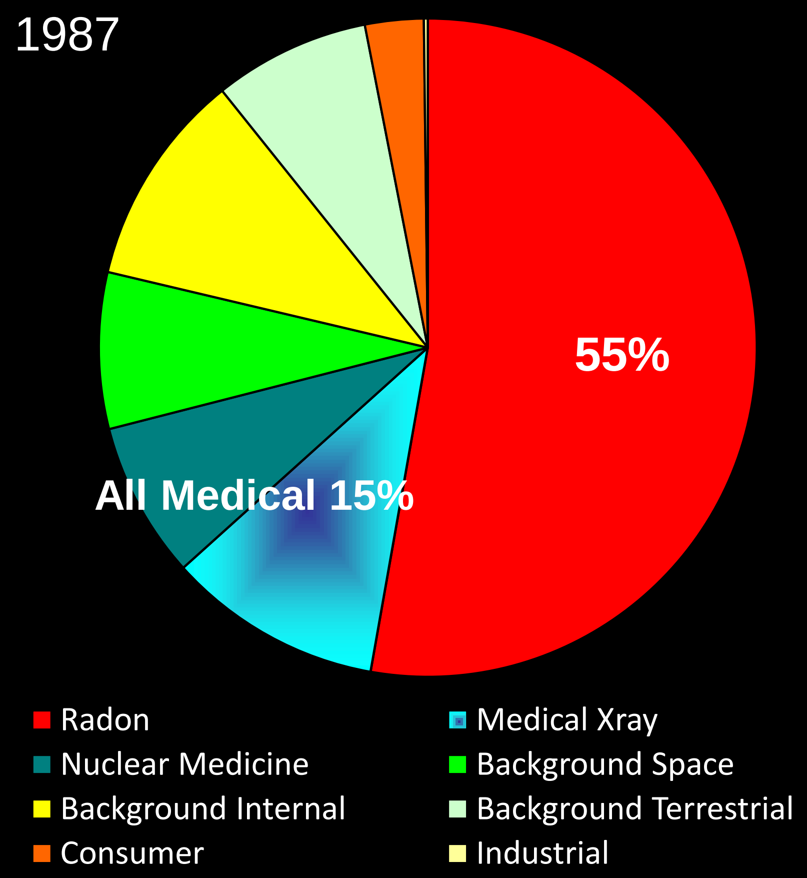
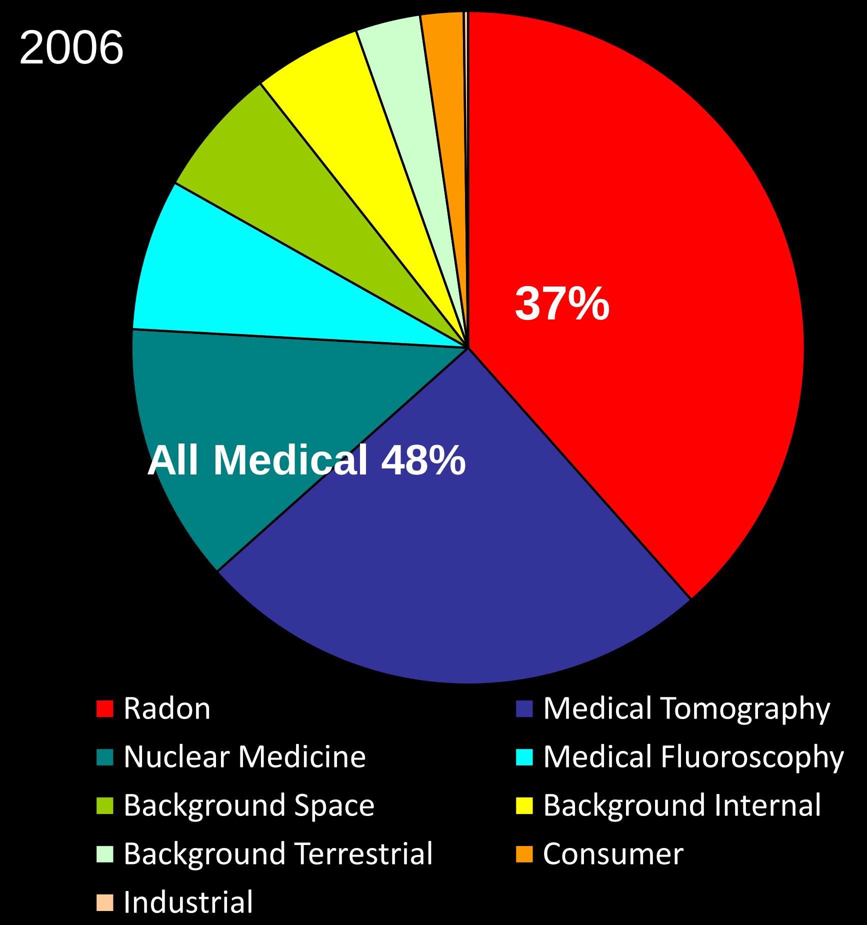
Sources of Annual Radiation Exposure for the General U.S. Population *(National Council on Radiation Protection and Measurements 1987 & 2006* Ionizing Radiation Exposure of the Population of the United States: Exposure to the Population of the U.S., *Report 93 & 160/ Bethesda, MD: NCRP)*





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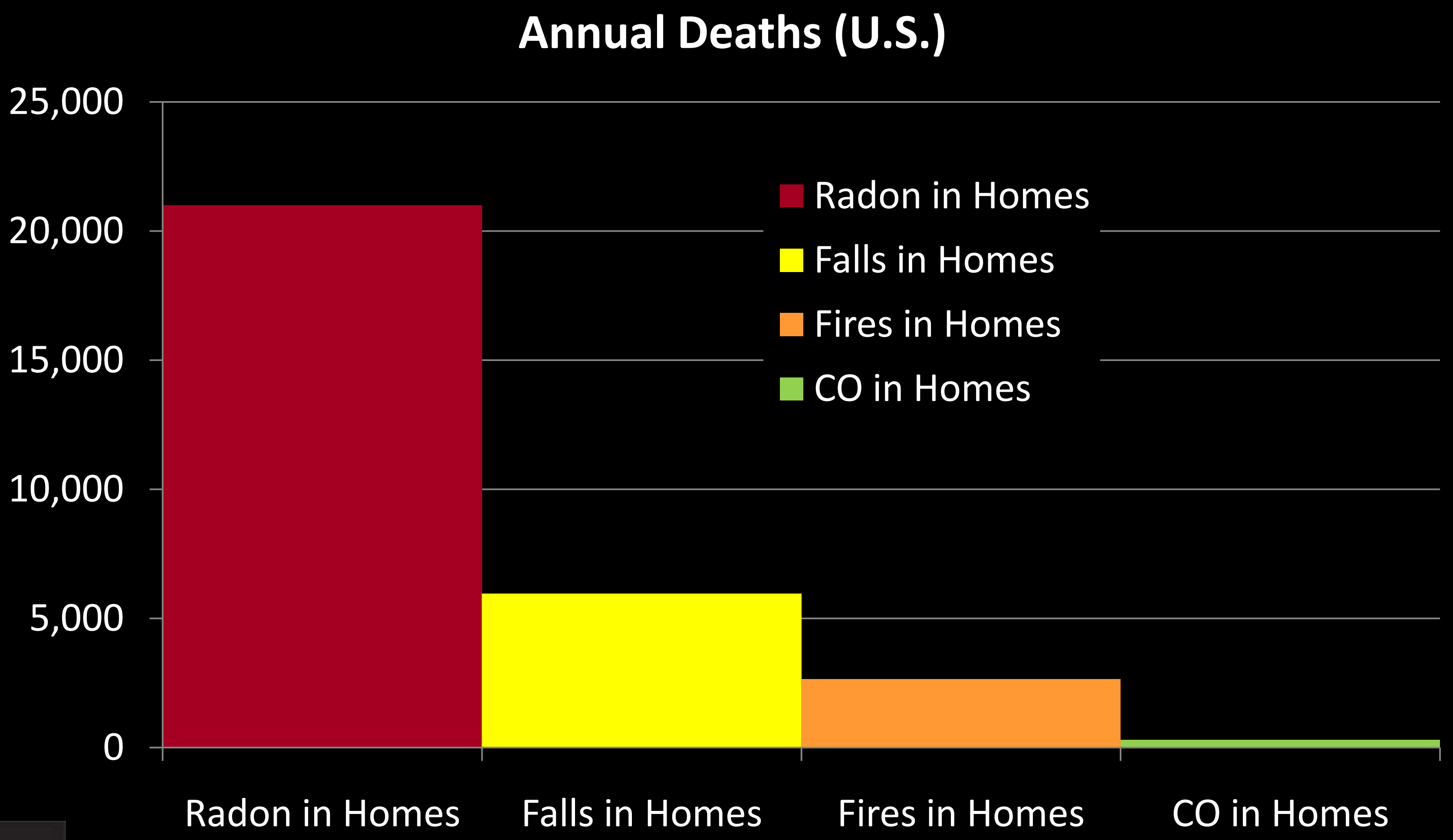
Radon Compared to Other Risks (EPA 2010 *A Citizen's Guide to Radon*; EPA; Consumer Product Safety Commission, 2003; *CDC*. *Unintentional* non–fire-related *carbon monoxide* exposures—United States, 2001-2003. MMWR Morb Mortal Wkly Rep. *2005*;54[2]:36-39)



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2. Radon Measurement

- Measurements for at least 3 months, preferably longer, are needed for estimates of annual average concentrations
  - Short-term measurements provide an indication of the actual (annual) radon concentrations
    - But short-term measurements are useful for time sensitive situations such as home buying
    - . . . and weatherization screening?
- **Quality assurance for radon measurement devices is highly recommended** in order to ensure the quality of measurement

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3. Radon Prevention and Mitigation

- The primary radon prevention and mitigation strategies focus on
  - Sealing radon entry routes and
  - Reversing the air pressure differences between the indoor occupied space and the soil through depressurization techniques
- My critique of this statement is that it could be interpreted that sealing entry routes is, by itself, an appropriate mitigation technique
  - There are differences in opinion about sealing as a stand alone technique especially in existing homes
  - There is consensus soil depressurization is most effective

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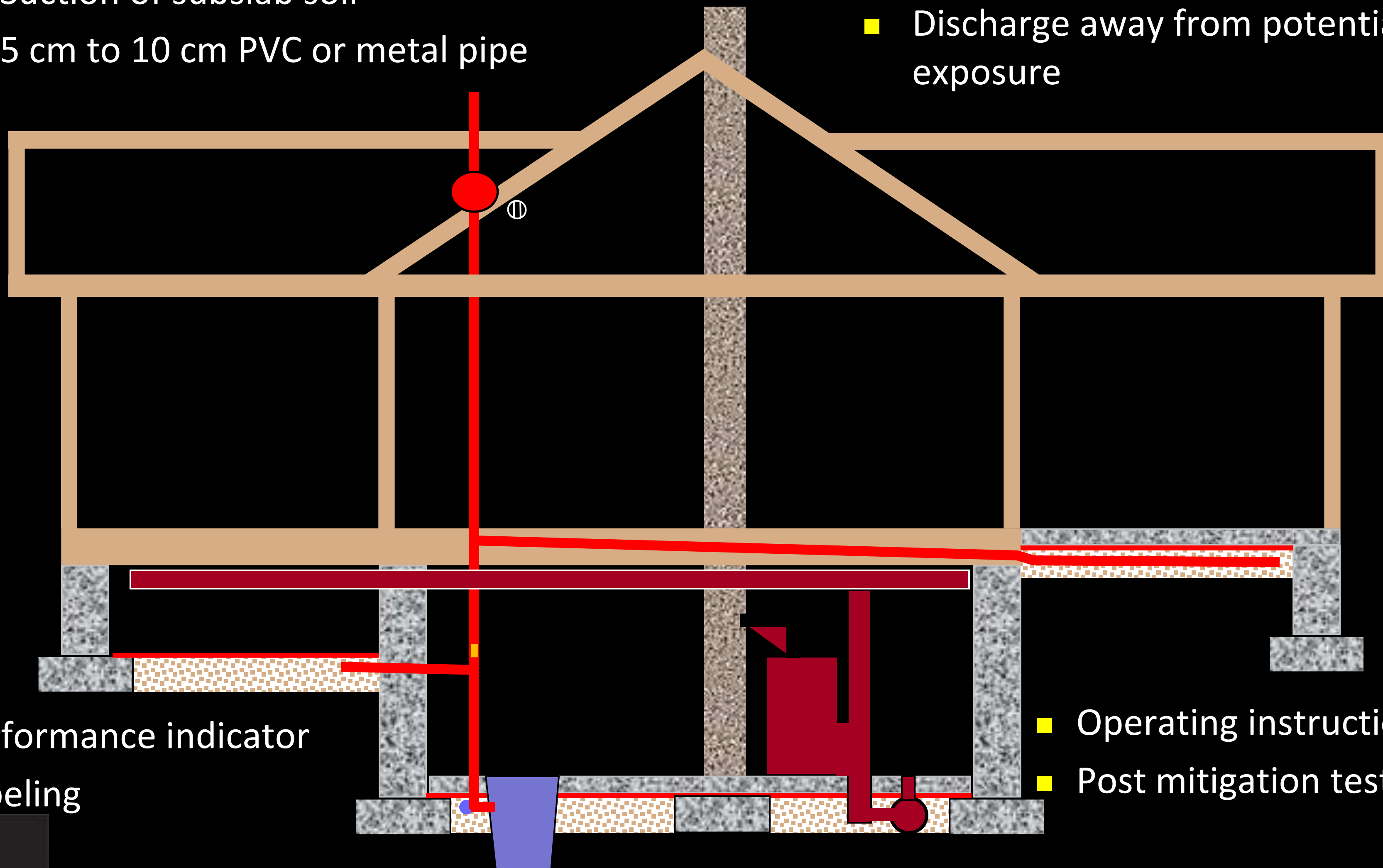
Active Soil Depressurization (ASD)

- Suction of subslab soil
- 5 cm to 10 cm PVC or metal pipe

- Inline fan outside
- Discharge away from potential exposure



- Performance indicator
- Labeling

- Operating instructions
- Post mitigation testing

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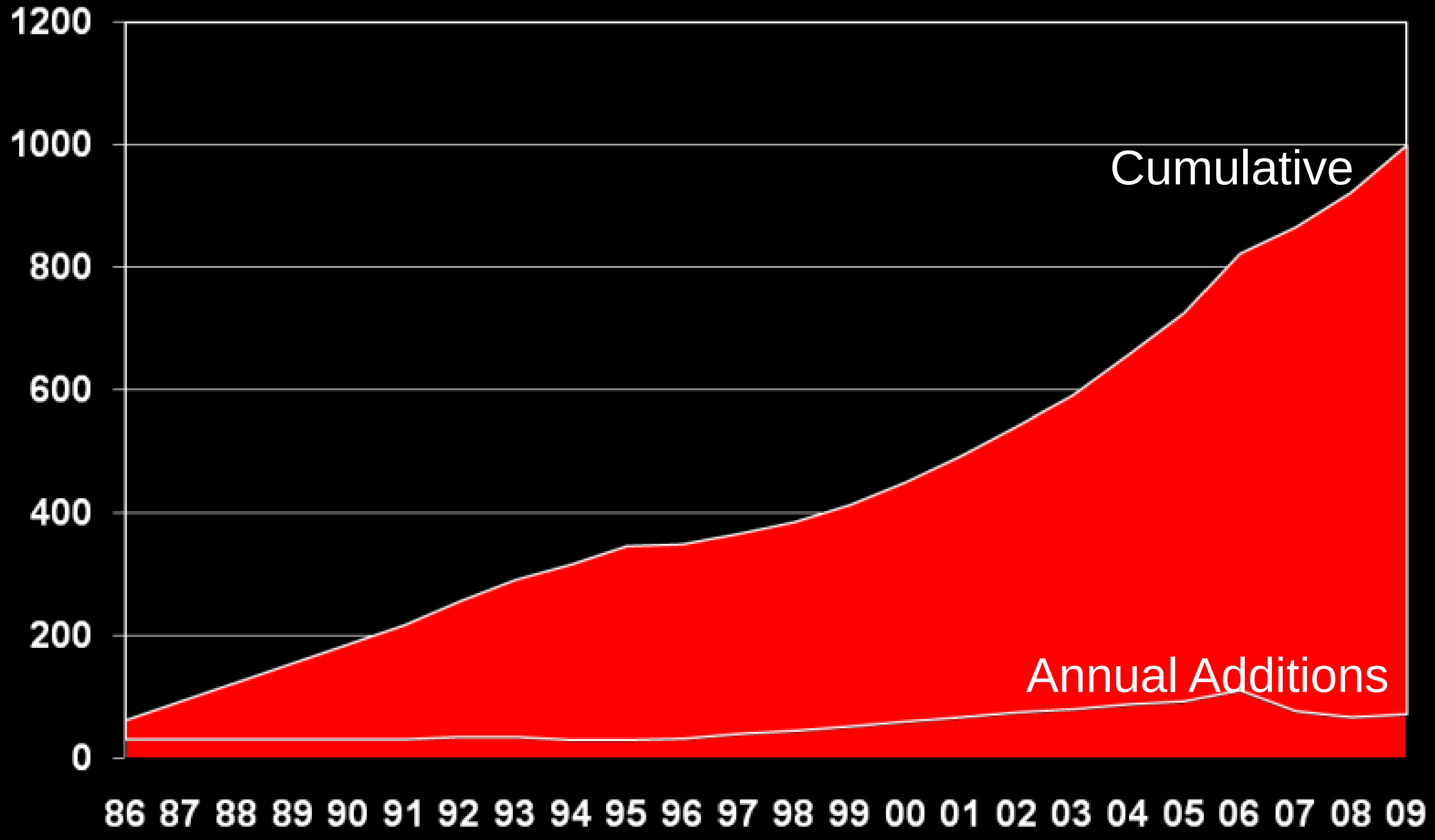
U.S. Radon Mitigation Systems (in 1,000s; Active Soil Depressurization Systems only; assuming 10 year fan life)



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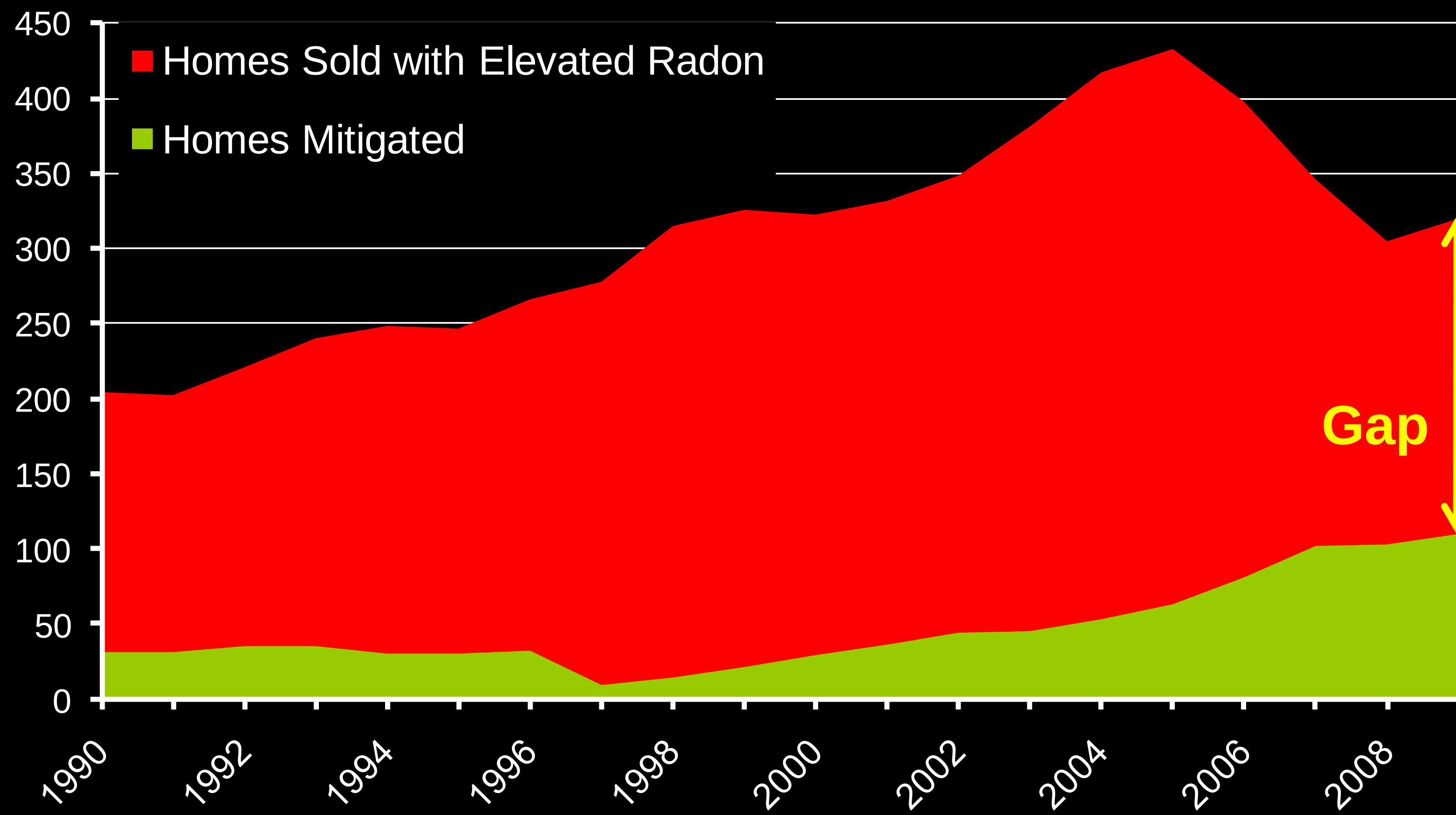
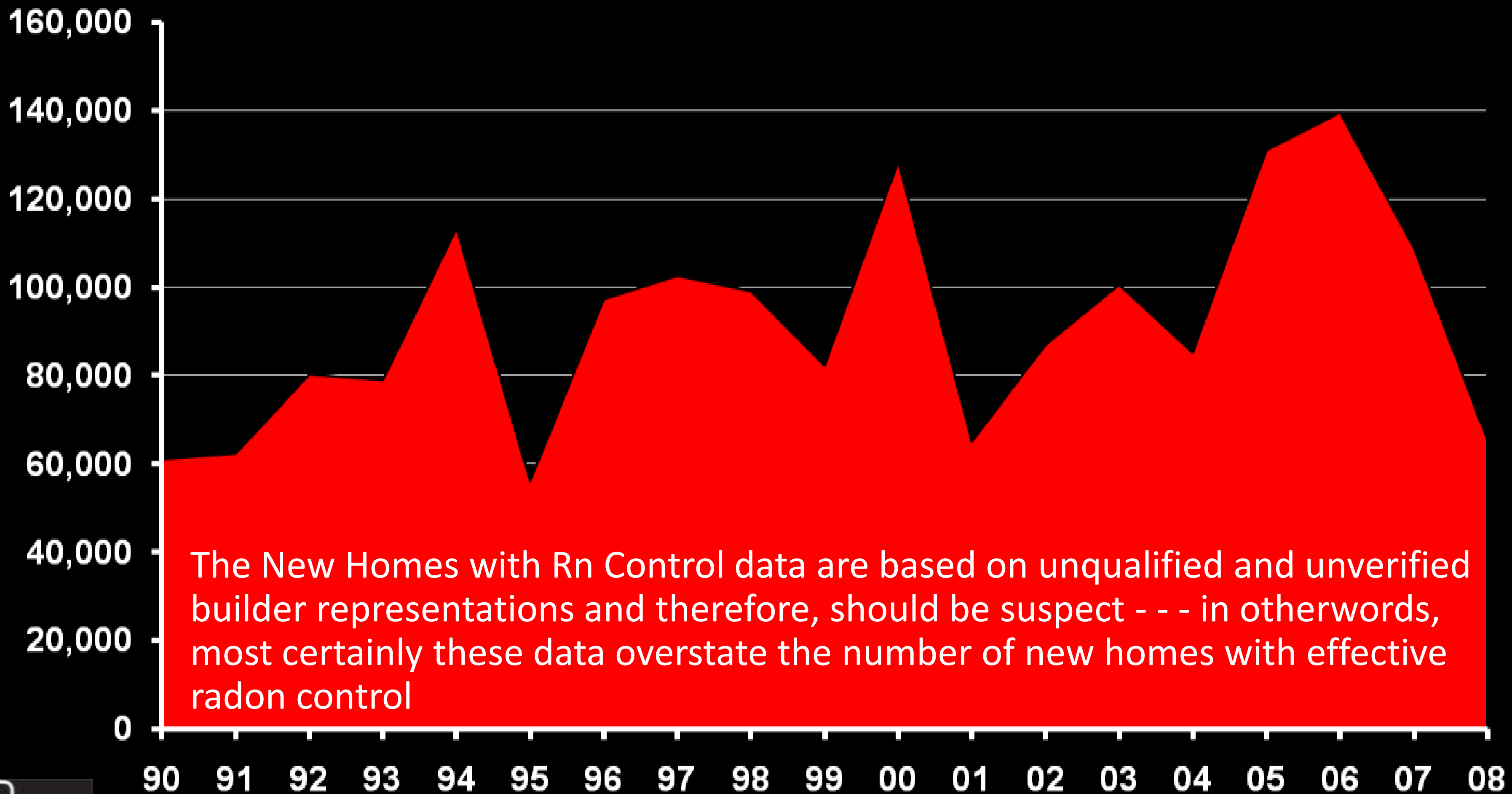
Existing U.S. Homes Sold with Elevated Radon versus Homes Mitigated (annual; in 1,000s)



The homes sold with elevated radon data are based upon the assumption that 7% of single family houses have elevated indoor radon (*cf* EPA's National Residential Radon Survey)

U.S. Radon Control in New Homes

(EPA, 2007, *Progress in Reducing the Risk from Radon in America's Homes*, May 2 draft and September 7, 2010 email from Phil Jalbert, U.S. EPA, Washington, DC)



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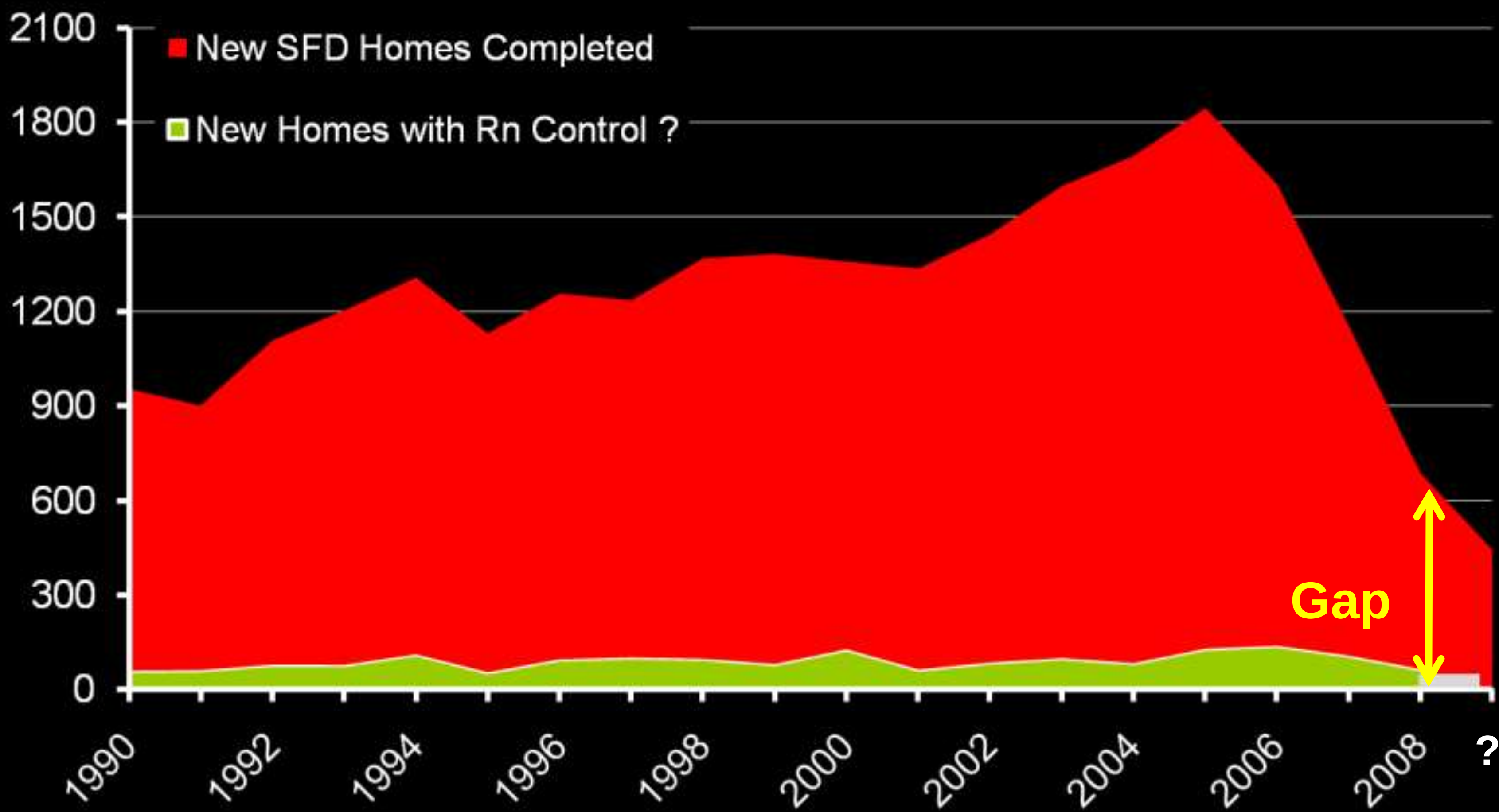
U.S. New Homes Completed versus New Homes with Rn Control Features? (annual; in 1,000s)



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4. Cost-Effectiveness of Radon Control Strategies

– A nation's choice of radon risk reduction techniques, prevention and testing/mitigation, can be based upon
  - An analysis of cost-effectiveness
    – In this approach, net health-care costs are set in relation to net health benefits for a variety of actions or policies
      » Providing an index which these actions can be prioritized
– Selected analyses indicate that preventive measures in all buildings are cost-effective where more than 5% of the current dwellings have radon concentrations above 200 Bq/m^3
  - Prevention tends to be more cost-effective than mitigation
    – In some low risk areas, the measurement costs are sometimes higher than mitigation costs
      » Due to the high number of homes that must have to be tested compared to the proportion of homes mitigated

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5. Radon Risk Communication

- Needs to be focused on informing different audiences
  - Recommending radon reduction action
- To develop a set of core messages, a cooperative effort is required involving
  - Technical experts and
  - Communication experts
  - **Notably absent is the importance involving cancer survivors**
    - **www.CanSAR.org**
- Radon risk messages should be
  - Kept as simple as possible
  - Quantitative information must be expressed in clear terms
- It is useful to place risk of lung cancer due to radon in comparison with other
  - Cancer risks or
  - Everyday risks in life

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Encouraging the Public to Take Action on Reducing Radon

- Disseminating radon risk information to the public is usually insufficient to promote either radon testing or mitigation
  - Rather, a program needs to persuade the public to take action
  - One reason for apathy by some is that they view radon as naturally occurring
  - **While radon is natural outdoors, indoors radon concentrations are the result of the way we design and build homes and how occupants use and operate the homes**
  - High indoor radon concentrations are a form of technologically enhanced natural radiation
    - **A colleague, Bill Field, describes indoor radon as a major environmental toxicant equivalent to a radioactive dirty bomb**

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Why Does It All Matter?

. . . Because There Victims

Cancer Survivors Against Radon (CanSAR) Founders

6. National Radon Programs

- In general, aim at reduction of
  1. Individual risk for people living with high radon concentrations and
  2. Overall population risk from the national average radon concentrations
- Should focus on
  - The identification of geographic areas at most risk
  - Raising public awareness about the risk of indoor radon exposure
- Key elements of a successful program include
  - Collaboration with other health promotion programs, e.g.,
    - Indoor air quality, anti-tobacco campaigns, cancer control
  - Training of building professionals and others
  - Building codes
  - Measurement during home buying is useful

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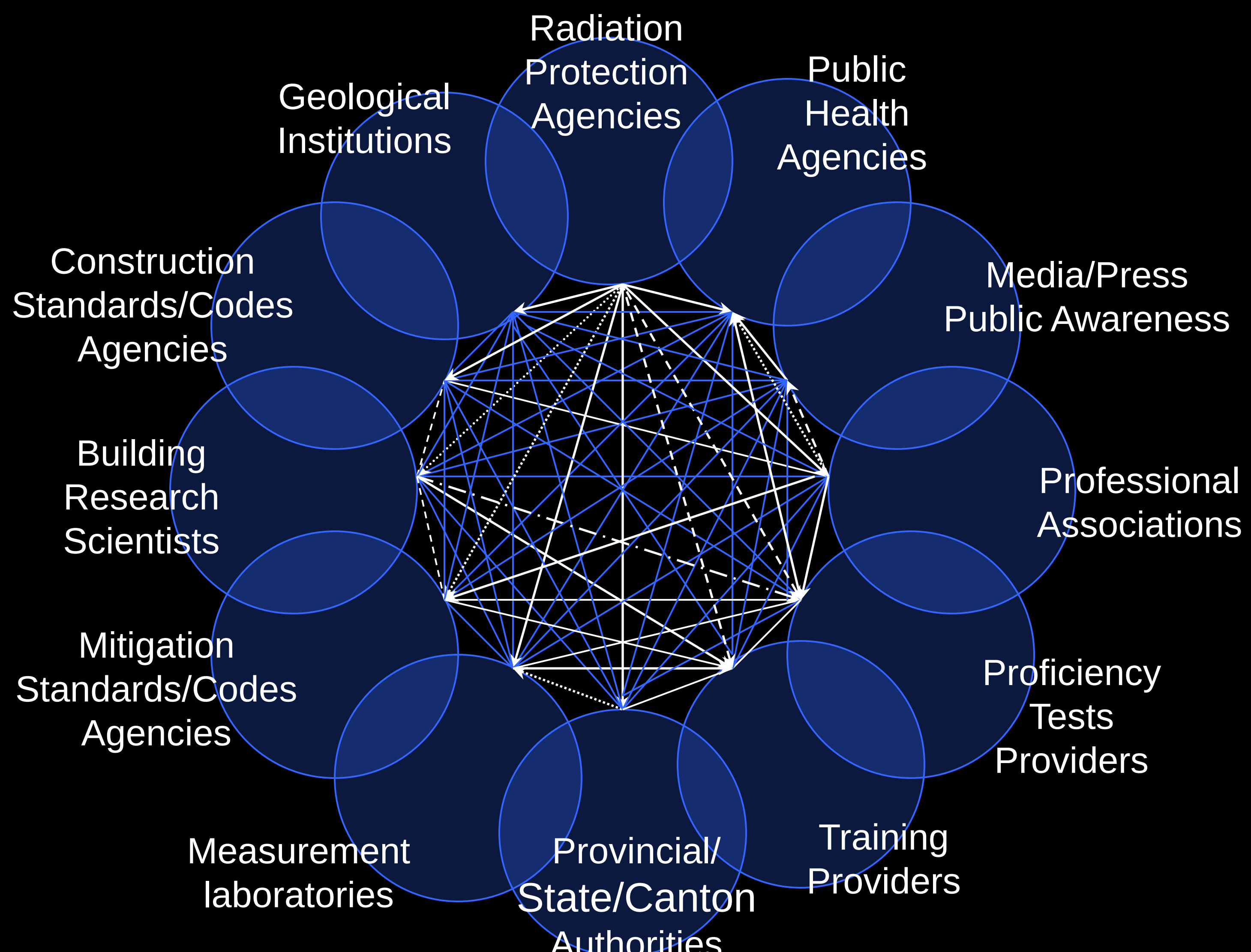
National Agencies and Stakeholders Involved in National Radon Program



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National Reference Level (1:2)

- Reference level reflects the maximum accepted average annual radon concentrations in a dwelling. The level may be
  - Strongly recommended (e.g., Canada, Ireland, US, UK) or
  - Mandatory (e.g., Czech Republic, Sweden, Switzerland)
  - In some cases, cites two reference levels, one for existing houses and a lower reference for new construction
- Reference level differs from the term "action level" in as much as the latter gave the impression that radon concentrations below that level were safe
- **WHO recommends a reference level as low as reasonably achievable**
  - **Based upon the latest scientific data, a level of 100 Bq/m^3 (2.7 pCi/L) is justified**
    - However, if this level cannot be implemented because of country-specific factors, the chosen reference level should not exceed 300 Bq/m^3 (8 pCi/L)

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National Reference Level (2:2)

- The decision to set a national reference level needs to take into account the prevailing economical and societal circumstances as well as various national factors such as
  - Distribution of radon
  - The number of existing homes with high radon concentrations
  - Prevalence of smoking
- **Countries with reference levels in the range of 100 to 300 Bq/m^3 should first improve their acceptance rate for measurement and mitigation**. For example. In the UK:
  - **Keeping the reference level at 200 Bq/m^3 while doubling acceptance and mitigation rates is estimated to increase the number of lung cancer deaths averted by a factor of 5 whereas**
  - **Reducing the reference level from 200 to 100 Bq/m^3 with the same acceptance and mitigation rates will only increase the number of lung cancer deaths averted by a factor of 2 (Gray et al. 1999)**

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Where are We at with Radon?

- Radon in U.S. homes:
  - Causes about **21,000** lung cancer deaths (LCD) each year
    - . . . or 1 LCD every **25** minutes
- ***There are <u>more</u> homes with elevated radon than any time in history!***
  - **Today, about 8 million compared to . . .**

    . . . less than 6 million in 1990
- EPA's radon measurement protocols have not been updated for 18 years and needed measurement standards have never been written
  - The AARST Standards Consortium has initiated a volunteer-base development of protocols

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