Radon in the Midwest and the World

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My Bio

• William J. Angell
  – Professor, University of Minnesota
  • Director, Midwest Universities Radon Consortium
    – U.S. EPA founded; serves 10 states
    – www.cce.umn.edu/radon
  – Chair, Prevention and Mitigation Working Group
    • World Health Organization’s International Radon Project
  – Past-President, American Association of Radon Scientists and Technologists
    – www.aarst.org or email director@aarst.org
  – Personal
Why Does It All Matter? 

... Because There Victims
"In 2004, I had a very bad cold, so my doctor performed a chest x-ray to check for pneumonia. I've never smoked, so you can imagine how shocked I was that he found a 4.5 centimeter mass in my left lung.

"Even though I've been a real estate agent for 31 years, I had never bothered to test my house for radon. I always informed my clients that radon testing prior to purchase was an option (to protect my liability), but truthfully, I really didn't care if they tested or not. "Now I had to wonder whether my lung cancer had been caused by radon exposure. While the doctor scheduled my surgery, I scheduled a radon test. The result was 10 pCi/l, (2 ½ times the EPA's Action Level). I had lived in the home for 12 years. Needless to say, I called a contractor to have a mitigation system installed.

"Two days later I had surgery. I thought I was surely going to die. When I woke up choking with tubes in my throat, panic set in. They had removed my entire left lung. I'm getting better. I can walk up to a mile. But, I can no longer dance, lift things, or exert myself.

"My clients now get a very personal testimonial about the importance of testing for radon."
Introduction

What’s New About Radon in 2010?

- **President’s Cancer Panel Report**

- **Policy and program recommendations:**
  - EPA consider reducing its current 150 Bq/m³ action level
  - Public and health care provider education be developed and disseminated to raise awareness of radon-related cancer risk
  - Development of improved residential radon testing methods
  - Tax incentives to encourage radon mitigation
  - Building code requirements for radon control in new homes
  - Radon testing at regular intervals in all day schools, care centers, and workplaces
WHO’s Radon Recommendations

Chapters/Working Groups

- Health Effects of Radon
- Radon Measurement
- Radon Control: Prevention and Mitigation
- Cost Effectiveness of Radon Control Strategies
- Radon Risk Communication
- National Radon Program Options

Glossary
WHO’s Radon Recommendations

Risk Communication

• How we have described radon
  • Radon is . . . naturally occurring

• How we should describe radon
  • Outdoors, radon is naturally occurring
  • Indoors radon concentrations are the results of how we design and build our homes

• In my opinion, this new way of describing indoor radon is
  • A fundamental paradigm shift
    • Puts responsibility on architects, builders, and RE agents
  • A powerful tool for radon risk reduction
WHO’s Radon Recommendations

National Radon Programs

• WHO recommends a reference level as low as reasonably achievable
  • Based upon the latest scientific data, a level of 100 Bq/m$^3$ is justified
  • **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)
Further Comments About National Reference Levels

• 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, two reference levels are cited, one for existing houses and a lower reference for new construction (e.g., Sweden)

• In Summer 2009, an advisory committee to the UK’s Health Protection Agency recommended lowering the UK’s reference level from 200 Bq/m³ to 100 Bq/m³

• Two weeks ago, the Swiss Federal Office of Public Health recommended lowering Switzerland’s
  – Mandatory action level from 1,000 Bq/m³ to 300 Bq/m³
  – Voluntary reference level from 400 Bq/m³ to 100 Bq/m³
Introduction

Purpose

- To offer a basic perspective of:
  - Radon health effects and risks
    - Tomorrow, Bill Field will cover this topic in greater detail
  - How radon enters homes and other buildings
  - How we remediation existing homes and control radon in new homes

- To offer an assessment of current radon policy and options
  - To suggest sources for further information
    - Cancer Survivors Against Radon www.CanSAR.org
    - Lead State Radon Contracts www.epa.gov/iaq/whereyoulive.html
    - Radon Professionals www.aarst.org
What is Radon?

Radioactive Gas

1. Causes Lung Cancer
2. Outdoors, Naturally Occurring
   - But indoors, human influenced
   ~ The we design, build and use our buildings
   → Primary exposure in the home
3. No Static Electrical Charge
4. Noble Gas - Inert (does not chemically react)
5. Colorless, Odorless, and Tasteless
   - Not Detected by Human Senses
What is the Evidence of Health Effects Associated with Radon Exposure?

- Lung cancer is the strongest documented health risk
  - 1970s – present
    - Cohort studies of underground miners
      - 1999 National Academy of Sciences comprehensive review
      - 2003 revised EPA risk assessment
  - 1980s – present
    - Residential case-control studies
      - 1988 UNSCEAR declared radon and radon decay products were Group 1 Human Carcinogens
  - 2000 – present
    - Pooling of residential case-control studies
      - North American, European, Chinese, and, underway, global
Highlights of Radon Health Effects Studies

• No safe amount of radon has been established
• The risk is linear
• There is a remarkable degree of agreement between
  – The underground miners cohort studies and the residential pooling studies
  – The two major residential pooling studies, North American and European
• U.S. EPA’s current risk assessment
  – 21,000 lung cancer deaths per year (residential exposure only)
    • Leading cause for never smokers
    • Second leading cause risk for smokers and former smokers
New U.S. Cancer Cases (Estimated 2010)

www.cancer.org/docroot/PRO/content/PRO_1_1_Cancer_Statistics_2010_Presentation.asp

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<th>Men</th>
<th>Women</th>
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<td>Lung &amp; bronchus</td>
<td>15%  Lung &amp; bronchus</td>
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<tr>
<td>Colon &amp; rectum</td>
<td>9%  Colon &amp; rectum</td>
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<tr>
<td>Urinary bladder</td>
<td>7%  Uterine corpus</td>
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<tr>
<td>Melanoma of skin</td>
<td>5%  Thyroid</td>
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<tr>
<td>Non-Hodgkin lymphoma</td>
<td>4%  Non-Hodgkin lymphoma</td>
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<tr>
<td>Kidney &amp; renal pelvis</td>
<td>4%  Melanoma of skin</td>
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<tr>
<td>Oral cavity</td>
<td>3%  Ovary</td>
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<tr>
<td>Leukemia</td>
<td>3%  Kidney &amp; renal pelvis</td>
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<tr>
<td>Pancreas</td>
<td>3%  Leukemia</td>
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<tr>
<td>All Other Sites</td>
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</table>

**Men**
- Prostate: 28%
- Lung & bronchus: 15%
- Colon & rectum: 9%
- Urinary bladder: 7%
- Melanoma of skin: 5%
- Non-Hodgkin lymphoma: 4%
- Kidney & renal pelvis: 4%
- Oral cavity: 3%
- Leukemia: 3%
- Pancreas: 3%
- All Other Sites: 19%

**Women**
- Breast: 28%
- Lung & bronchus: 14%
- Colon & rectum: 10%
- Uterine corpus: 6%
- Thyroid: 5%
- Non-Hodgkin lymphoma: 4%
- Melanoma of skin: 4%
- Ovary: 3%
- Kidney & renal pelvis: 3%
- Leukemia: 3%
- Pancreas: 3%
- All Other Sites: 22%

*Excludes basal and squamous cell skin cancers and in situ carcinomas except urinary bladder.
Source: American Cancer Society, 2010.*
# U.S. Cancer Deaths (2010 Estimated)

www.cancer.org/docroot/PRO/content/PRO_1_1_Cancer_Statistics_2010_Presentation.asp

## Men

<table>
<thead>
<tr>
<th>Type</th>
<th>Deaths</th>
<th>Percentage</th>
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<tr>
<td>Lung &amp; bronchus</td>
<td>299,200</td>
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<tr>
<td>Prostate</td>
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<td>11%</td>
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<td>Colon &amp; rectum</td>
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<td>9%</td>
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<tr>
<td>Pancreas</td>
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<td>6%</td>
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<tr>
<td>Liver &amp; intrahepatic bile duct</td>
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<td>4%</td>
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<tr>
<td>Leukemia</td>
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<td>4%</td>
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<tr>
<td>Esophagus</td>
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<td>4%</td>
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<tr>
<td>Non-Hodgkin lymphoma</td>
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<td>4%</td>
</tr>
<tr>
<td>Urinary bladder</td>
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<td>3%</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td></td>
<td>3%</td>
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<tr>
<td>All other sites</td>
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<td>23%</td>
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## Women

<table>
<thead>
<tr>
<th>Type</th>
<th>Deaths</th>
<th>Percentage</th>
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<td>Lung &amp; bronchus</td>
<td>270,290</td>
<td>26%</td>
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<tr>
<td>Breast</td>
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<td>15%</td>
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<td>Colon &amp; rectum</td>
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<td>Pancreas</td>
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<td>7%</td>
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<tr>
<td>Ovary</td>
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<td>5%</td>
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<tr>
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<tr>
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<td>3%</td>
</tr>
<tr>
<td>Uterine corpus</td>
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<td>3%</td>
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<tr>
<td>Liver &amp; intrahepatic bile duct</td>
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<td>2%</td>
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<td>Brain/ONS</td>
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<td>2%</td>
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<tr>
<td>All other sites</td>
<td></td>
<td>24%</td>
</tr>
</tbody>
</table>

ONS=Other nervous system.

Source: American Cancer Society, 2010.
2010 Cancer Deaths in the U.S.

- About 570,000 Americans died of cancer
  - Lung cancer is the leading cause of U.S. cancer deaths
    - About 223,000 new lung cancer cases expected
      - 157,000 will die from lung cancer
    - The most important carcinogens
      - Tobacco smoke followed by
        - Radon ~ 21,000 lung cancer deaths per year
          » Secondhand smoke ~ 3,000 lung cancer deaths per year
          » Asbestos
  - The dominate forms of cancer deaths are:
    - For men: 1) lung, 2) prostate, 3) colon, and 4) rectum
    - For women: 1) lung, 2) breast, and 3) colon
Sources of Annual Radiation Exposure for the General U.S. Population


1987
- Radon: 55%
- All Medical: 15%

2006
- Radon: 37%
- All Medical: 48%
U.S. EPA Threshold for Action

• EPA’s Threshold for Action has long been 4 pCi/L
  – At this exposure in the home, the risk of dying from lung cancer is 2.3% for the general population - - - greater than 1:50
  • > risk of dying in a motor vehicle accident
• How does the risk of indoor radon compare to other risks?
  – Accidental residential carbon monoxide exposure kills approximately 300 U.S. citizens each year compared to 21,000 radon deaths
  – Residential fire deaths average less than 3,000 each year compare to 21,000 from radon
• The World Health Organization has recommended that countries consider reducing radon reference levels to 2.7 pCi/L
Radon Compared to Other Risks


Annual Deaths (U.S.)
Radon Concentrations

0.4 pCi/L *U.S. annual average outdoors
1.3 pCi/L * U.S. annual average indoors in homes (living areas)

pCi/L is a unit of radon radioactivity (or ‘activity’) concentration
1 pCi/L = 2.2 radioactive disintegrations per minute per liter

100s - 100,000s pCi/L

Radon
Radium
Uranium
U.S. Radon Zone Map: Okay for Big Picture

- Expected average short term Radon (pCi/L):
  - **Red** = Zone 1
    - > 4.0
    - High probability
  - **Orange** = Zone 2
    - 2.0 to 3.9
  - **Yellow** = Zone 3
    - < 2.0
    - Low probability
  - Areas of high and low radon may be found in any zone
Maps are Less Helpful at the Community Scale (Must test each house!)

Test Results
- < 4 pCi/L
- 4 - 10
- 10 - 12
- 12 - 16
- 16 - 20
- 20 - 30
- > 30

Source: Mike Mudrey, 2005, UW-Madison
## Mean Indoor Radon Concentrations: Midwest States (pCi/L) (EPA State Surveys, 1986-1992)

<table>
<thead>
<tr>
<th>State</th>
<th>All Houses</th>
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<tr>
<td>Indiana</td>
<td>3.7</td>
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<td>Iowa</td>
<td>8.9</td>
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<td>Kentucky</td>
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<td>Michigan</td>
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<td>Minnesota</td>
<td>4.8</td>
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<tr>
<td>Missouri</td>
<td>2.6</td>
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<tr>
<td>Ohio</td>
<td>4.3</td>
</tr>
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<td>Wisconsin</td>
<td>3.4</td>
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<table>
<thead>
<tr>
<th>State</th>
<th>All Houses</th>
<th>Basement</th>
<th>Nonbasement</th>
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<tbody>
<tr>
<td>Illinois</td>
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<td>NA</td>
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<tr>
<td>Wisconsin</td>
<td>3.4</td>
<td>3.5</td>
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</table>
How Does Radon Enter Homes?

• The overwhelming majority of radon entry is due to air pressure differences between the soil and indoors
  – The largest cause of this pressure variance is due indoor-outdoor temperature differences
  – In large buildings (e.g., schools) operation of ventilation systems may be very important
• Usually unimportant are
  – Emanation of radon from building materials
  – Well water transport of radon
  – Diffusion transport
Indoor Radon Concentrations . . .

- Are not strongly correlated with ventilation rates, e.g.,
  - Very leaky or drafty houses may have elevated radon
  - Very airtight or energy-efficient houses may have low radon concentrations
    - However, the more airtight a building may be, the greater the suction on the soil
- For all practical reasons, it is virtual impossible to reduce indoor radon concentrations by sealing cracks and holes in foundations
The Costs of Radon Testing and Control

• Radon testing by
  – Property owners typically costs $5 to $30
  – Professionals typical cost $100 to $150
    • Such as in home sales

• Radon control typically costs
  – $1,000 to $1,800 in existing homes
  – $300 to $600 in new homes (National Association Home Builders)
    • $300 for passive systems
    • $600 for active or fan-driven systems
Radon Control

- Suction of subslab soil
- 3 to 4 inch PVC
- Inline fan outside
- Discharge away from potential exposure
- Performance indicator
- Operating instructions
- Post mitigation testing
Since Radon Testing and Control are Inexpensive, There Must be No Problem

• NOT TRUE

• The number of U.S. homes with elevated indoor radon has increased by one-third over the past 20 years
  – More new homes with elevated radon are added to the housing stock than the number of problem homes that are mitigated

• Very few rental apartments have been tested and tenants are in a weak position to obtain radon test results and radon control
Radon Policy in Other Countries

• Norway has required test of all new homes
  – Must be less than reference level
  • Goal for all new homes to have radon \( \frac{1}{4} \) of reference level

• Sweden is most advanced
  – Local health authorities have the power to order
  • Radon testing
    – Used for rental housing
  • Radon mitigation
    – 50% grant up to 1500 Euros for owner-occupied
      » Switzerland offers a tax credit

• Switzerland has established goals, e.g.,
  – All elevated homes and schools must be mitigated by 2014
Countries with Radon Control Building Code Requirements

- Canada (2011)
- Czech Republic
- Denmark
- Finland
- Ireland
- Latvia
- Norway
- Slovak Republic
- Sweden
- United Kingdom
State Radon Policy Considerations
(Environmental Law Institute, 2010) (from most to least common)

• General disclosure in home sales
• Certification or licensing of radon professionals
• Building code requirements for new homes
• Mandatory testing of childcare facilities
• Radon warning statement in home sales
• Mandatory testing of schools
• Building code requirements for new schools
• Testing of state owned or leased buildings
• Radon warning statement in residential leases
# Midwest States and Radon Policy

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- Reduces Child and Staff Rn Exposure
- Demonstrates “Walking the Talk”
- Environmental Justice
Radon Policy Priorities

1. For all ground contact units:
   A. Statewide building code requirements
      1) Low-rise residential buildings
      2) Schools and child care facilities
   B. Mandatory radon testing prior to:
      1) Leasing an apartment or other dwelling unit
         – Especially important ~ environmental justice
      2) Home sale

2. Radon testing of ground contacted spaces in all:
   A. State owned or leased buildings
   B. Schools and child care facilities every 5 years

3. Certification or licensing of radon professionals
Summary

• Indoor radon is a very serious environmental health risk
• It is easy and inexpensive to
  – Test for indoor radon
  – Remediate high concentrations in existing buildings
  – Prevent high concentrations in new construction
• Public policy is needed ~
  – Building codes
  – Testing
    • Rental housing
    • Homes for sale
    • Public buildings including schools and day care facilities
  – Strong certification or licensing programs
Questions?

Comments?