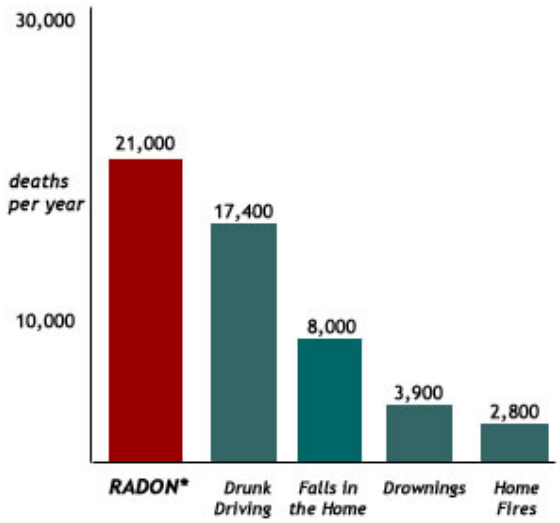
Radon & Environmental Health
Spring 2015 Environmental Studies Senior Seminar (ENVS 0401 A&B)

Background/Context

Radon—a byproduct of uranium decay—is a naturally occurring radioactive gas present in soil, air and water that can rise to unhealthy levels in indoor environments. In fact, radon is the second leading cause of lung cancer in the US after smoking, with an estimated 15,000 to 22,000 lung cancer deaths per year. Smoking is also a radon risk multiplier—if you smoke *and* you are exposed to radon in your home, your risk of getting lung cancer is especially high. [1] An Environmental Protection Agency (EPA) publication geared towards physicians includes the following graphic putting the radon health risk in context of other common risks.[2]



In the built environment, radon primarily escapes from surrounding soil or bedrock into a building's air, with the amount varying based on geology, soil type, and building construction. A salient trend in Vermont is that building "tighter" to make homes more energy efficient can increase radon concentrations if there is insufficient ventilation. Second, well water that contains radon may increase the level of radon gas in a building—for example during dishwashing or showering. Work in the New York City area is also bringing to light a third potential exposure pathway via the use of natural gas for stove-top cooking when that gas is sourced from geologic formations with high levels of radiation.[3]

Baseline radon levels for Vermont are noted as 0.4 picocuries per liter (pCi/L) for outdoor air and 2.5 pCi/L for indoor air.[4] There are mitigating strategies for indoor environments with radon concentrations above the EPA action level of 4.0 (pCi/L). To get a sense of the scale of this issue for Vermont, the Vermont Department of Health (VDH) estimates that 1 out of every 10 homes has elevated levels that need to be mitigated (based on the testing of over 15,000 homes from 2000-2010).[5] In comparison, national estimates are that 1 out of every 15 homes have unsafe radon levels.[6] However, even learning of elevated radon levels does not always lead to action. A 2010 study of 120 homes in Vermont with radon levels above 4 pCi/L, showed that only 34 (28%) had installed mitigation systems.[7] This percentage increased to 34% in 2013 and 39% in 2014.[8]

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[1] http://healthvermont.gov/enviro/rad/Radon.aspx
[2] http://www.epa.gov/radon/pubs/physic.html
[3] http://saneenergyproject.org/our-programs/radon/
[4] David Grass, personal communication
[5] http://healthvermont.gov/hv2020/documents/hv2020_behaviors_enviro.pdf
[6] http://www.lung.org/healthy-air/home/resources/radon.html
[7] http://healthvermont.gov/hv2020/documents/hv2020_behaviors_enviro.pdf

Despite evidence of elevated levels and clear risks to human health, Vermont is far from universal testing and mitigation. The Vermont state legislature has seen several radon policy proposals put forth through the 1990s for mandatory radon testing in schools (introduced in House and Senate in 1994, again 1997-98), mandatory testing with real estate transfers (1994), and for testing all new and existing residential dwellings (1996). None of these bills moved forward. In the absence of legislation requiring testing, the VDH offers free test-kits for radon. Tests have been conducted in 20,625 Vermont homes out of the approximately 324,000 residential units in the state.[9] While Vermont law does not require a radon test as part of a real estate transaction, if radon testing has been done in the past, the buyer must be notified.[10] Lastly, the VDH has made it a programmatic strategy to conduct radon testing in schools. To date about 65 of Vermont's almost 300 schools have been tested, and the VDH uses a portion of its budget and grant funds to mitigate schools with elevated levels.

Several additional factors add to the challenge of fully addressing radon. Chief amongst these is the "facelessness" of this issue. Not only is radon itself tasteless, odorless, and colorless but since it is naturally occurring, there is no attributable polluter. There is no way to know if it is in your home or school environment without testing for it. There is a long latency period between exposure until the onset of illness. Further, it is an omnipresent yet highly variable pollutant (levels can vary daily, weekly, seasonally; radon in one house doesn't mean there will be radon in a neighboring house). Lastly, funding for radon programs can be inconsistent—e.g. Vermont already relies on year-to-year grant funding to support many of its efforts and the 2015 federal budget reduced EPA funding for grants related to radon abatement.[11]

Projects

The primary partner for your project research this semester is David Grass '99, Environmental Health Surveillance Chief with the VDH who oversees Vermont's Radon Indoor Air Program. Secondary partners / resource contacts for your work include Rebecca Ryan, Senior Director of Health Education and Public Policy for Vermont with the American Lung Association of the Northeast, Jon Kim with the Vermont Geological Survey, and Peter Crowley with the Association of Vermont Radon Industry Professionals (AVRIP). Below are a suite of four key research areas that our partners have identified as instrumental in advancing radon efforts in the state and which will be the focus of four student project teams:

1) Assessing Spatial Patterns and Causalities

In almost all cases, radon contamination is derived from the Earth, from bedrock, sediment or groundwater sources that contain elevated radionuclides (e.g. uranium, thorium and radium). Given that radon is an inert gas (produced by natural radioactive decay), it is free to migrate upward where it can become trapped in buildings. Natural decay of radon yields ionizing radiation (alpha particles) that are carcinogenic, so understanding factors that control spatial distribution of radon is an important component of the broader public health initiative to address radon as a cause of lung cancer.

- Investigate whether there is a correlation between potential groundwater sources of radon (e.g. well water with elevated uranium and radium in Colchester and Milton) and radon indoor air test results.
- Examine existing Vermont radon database to ascertain testing coverage and areas of uncertainty

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[8] http://healthvermont.gov/hv2020/dashboard/environmental.aspx
[9] http://quickfacts.census.gov/qfd/states/50000.html
[10] http://healthvermont.gov/enviro/rad/Radon.aspx
[11] http://www.nytimes.com/aponline/2014/03/05/us/ap-us-obama-budget-agencies.html?_r=0

- Determine geologic setting for existing elevated radon test results , including mapping of high risk areas and deploying short-term test kits if database indicates areas of special concern. Potential areas of focus might include Bristol, Castleton, or Poultney.
- Research on natural gas as a possible radon source, especially for gas derived from black shales with naturally-elevated radionuclides

These efforts will help inform policy by providing a better sense of the scope and scale of the issue

2) Increasing the Saliency of Radon

As noted above, there is no way to know if radon is in your home, work, or school environment without testing for it. The key outcome for any outreach and education initiative is therefore increased testing paired with mitigation when a problem is identified. While the overall goal of this project team will be to increase the saliency of radon for Vermonters, there are several options for how you could approach this. These include (but are not limited to):

- Narrative development to help us get over the "facelessness" of radon. Who are the people who get lung cancer in Vermont from radon? This could take the form of a written piece, audio clips, or videos. These narrative stories could also be quite influential to policy discussions. For an example, see "Eddie's Story" at: http://www.gotradonvt.com/Got_Radon/Radon_Now_What.html
- A written piece (e.g. a news feature or editorial) that helps make this faceless, nameless, polluter-less issue more of a palpable risk.
- Develop a case-study narrative of a school mitigation, documenting and publicizing testing and mitigation efforts in Vermont schools. The heightened awareness that this case-study could bring could translate into more homeowner testing. There is a school mitigation project in Rutland County set to begin in February. Further, since school testing is a legislative priority, the case study of how this mitigation plays out (costs, timeline, etc.) could inform policy recommendations.
- Research the most effective ways for the VDH to "advertise" about radon. The VDH just developed a series of advertisements regarding radon and smoking for National Radon Awareness Month, but are they are unsure if ads are the most effective use of their dollars.
- Devise strategies for targeting key audiences. The VDH's most recent grant application to the EPA's State Indoor Radon Grant Program (SIRG) has a suite of goals surrounding the placement of educational materials and groups to target with the goals to increase testing. These include doctor's offices, reaching parents of new children through pediatricians, the For Sale By Owner community, real estate agents, builders/contractors/home inspectors, and Town Health Officers.

3) Life Cycle and Relative Risk Analytics

Two themes from this class are addressed in this section: interdisciplinary modeling of risk and risk-risk tradeoffs. In the first three points below, we will use integrated assessment models to estimate and quantify environmental risks and risk reductions. Second, while a comprehensive assessment of all risks associated with radon, and environmental toxins in the home, more generally, is beyond the scope of this class, we have the tools to assess one potentially important ancillary risk: air pollution and greenhouse gas emissions from power generation needed to run radon abatement technology.

- Integrated assessment of radon in the home. Using VDH case study, report pre-treatment radon levels, post-treatment radon levels and employ known mortality dose-response function to estimate mortality risk reduction. Using VDH data, estimate cost/pCi/L and benefits.
- Estimate power consumption from radon abatement technology. Use methodology from Graff-Zivin et al. (2014) to estimate power plant response. Use integrated assessment to compute health risk from subsequent power generation.
- Report radon's relative risk relative to other environmental risk generated by use of abatement technology. Where do the risks manifest? In-state, regional?
- Develop benefit-cost analysis for LCA of new "radon resistant" construction and compare to results for mitigation in existing homes/schools.*
- Conduct life-cycle analysis (LCA) of radon abatement technology beginning with emission estimates from CMU EIO-LCA tool.*

**To be completed time permitting*

4) Policy Research and Development

The American Lung Association of the Northeast is just beginning a two-year policy process around radon. They—and AVRIP—feel that moving towards mandatory testing in schools should be the first legislative priority, both because of the priority for protecting children's health, but also because it might be the most politically feasible legislation to move forward. Currently, nine states have laws surrounding school testing. Key research that is needed to advance the conversation in Vermont includes:

- How are the policies in these other states actually playing out "on the ground". How much does it cost, what are the compliance rates, how is it enforced, are they making progress towards any targets/goals set, what kind of follow-up is paired with required testing, etc.
- What caused the VT bills from the 1990s to not advance? Who/What are the key constituencies that need to be reached?
- One of the first anticipated questions from legislators is, "What would be the cost to schools—both for testing and for mitigation if necessary?" AVRIP will be offering its mitigation services for select schools on a pro-bono basis as a community service project. Using case study data for one of their school remediation projects in addition to remediation projects that the VDH has completed, you could help detail a mitigation cost per school.
- If time allows, other avenues of research could include:
  - Assessing the feasibility of non-legislative mechanisms for moving the same goals forward
  - Assessing increasingly comprehensive legislative proposals including required testing for all day care facilities, public health facilities and rental housing; disclosure statements for real estate transactions; and certification for mitigation professionals, required mitigator permits, and post-mitigation reporting.

Key research documents for this team include:

- The National Council of State Legislatures' summary of state radon statues (http://www.ncsl.org/documents/environ/Radon_Statutes_2013.pdf)
- The Environmental Law Institute's Database of State Indoor Air Quality Laws (http://www.eli.org/buildings/database-state-indoor-air-quality-laws)
- The Environmental Law Institute's publication on issues and options related to state radon policies (http://www.eli.org/sites/default/files/eli-pubs/d1_13.pdf)