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Radon Reduction, Improvement of Indoor Air Quality, and Energy Savings through an Original Ventilation System

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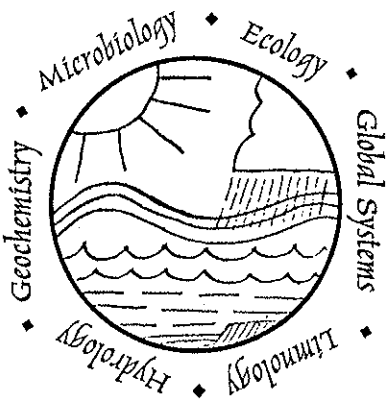

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ABSTRACT

This study evaluated the improvement of indoor air quality and energy savings achieved by an original solar ventilation system installed at test sites exhibiting elevated radon levels. Conventional residential energy conservation measures that limit air exchange rates between the indoors and outdoors have been shown to increase concentrations of radioactive radon decay products as well as other indoor air contaminants. Growing concern about radon lung cancer risks, carbon monoxide poisoning, and the "sick building syndrome" have increased demand for improved indoor air quality. Due to added heating and cooling loads, ventilation generally incurs substantial installation and operational costs. All commercially available radon mitigation systems, even those equipped with heat recovery devices, operate with net energy loss, and few alleviate other indoor air pollutants.

The ventilation system investigated combines energy conservation with low-cost radon reduction and indoor air quality management. Drawing on established mitigation techniques of ventilation, air supply and pressurization, the Solar Radon Reduction System (SRRS) provides energy-efficient make-up air for combustion appliances and stack effect losses. Indoor air quality is improved through dilution, slight pressurization, and reduced radon

infiltration with induced-draft ventilation. Solar heating of intake air enables the SRRS to operate with energy gain during cold weather, and the blower provides low-energy summertime cooling when outdoor temperatures drop below indoor levels.

The system was installed at six homes in Waterloo and Cedar Falls, Iowa, and a detailed assessment was conducted of the extent that the SRRS reduced radon levels and provided energy savings as well as how the system could be improved. Blower door tests were initially conducted to characterize the airtightness of each house. Electronic control units to trigger system operation based on radon levels and intake temperatures were devised, and PC data acquisition systems were installed at each site. The research methodology included synchronized hourly radon concentrations collected at the test homes and a "control" house maintained with closed conditions over five 10-day test periods. Operational modes tested included radon-trigger, temperature-trigger, and combined trigger system performance. Outlet temperatures and fan status were continuously recorded at five test homes, and dataloggers were additionally placed at two of the sites to measure inlet, outlet and basement temperature and humidity, solar radiation, and outdoor-basement pressure differentials. Fan rates were added to infiltration estimates for each house to determine system effects on house air time constants.

The SRRS was found to improve overall indoor air quality with energy benefits and to significantly reduce radon, up to 73% from closed house levels as high as 21 pCi/L. SRRS effectiveness was found to be related to the duration of system operation and dwelling leakiness; increased weatherization and fan capacity appear to enhance pressurization and dilution gains. An inverse correlation of winter temperatures and solar availability was found to be beneficial for solar heat collection. The control house exhibited fluctuating radon levels apparently due to weather-related factors, which correlated closely with radon trends particularly at the more leaky test sites. Thus a separate closed house was found to serve as an appropriate reference for simultaneous multi-home remediation comparisons. This study shows the SRRS is a promising energy-efficient indoor air improvement technique that can attain radon concentrations below the EPA guideline in existing dwellings with elevated levels.