Day 1: Second Morning Session

What are the challenges to bringing about health-promoting changes in indoor environments?

William J. Fisk, B.S., M.S.
Lawrence Berkeley National Laboratory

Mr. William Fisk introduced the topic of how to release market forces to influence building professionals and decision makers to make their buildings more health-protective. Most building designers and managers focus on immediate functional requirements (space requirements, temperature ranges, and attractive design), meeting building-code requirements at minimum cost, and providing a facility that is marketable and will attract a good rental return. The impact of design considerations on indoor environment quality, occupant health, and productivity is generally not emphasized. This places primary importance on first costs, perhaps tempered by measures that will reduce long-term maintenance costs; indoor environmental quality is a secondary consideration. Building professionals are often isolated from the consequences of decisions that result in suboptimal indoor environment quality. Overcoming this type of barrier to change requires providing incentives (benefits) or demonstrating the economic penalties of ignoring indoor environment quality issues.

Mr. Fisk's key points included the following:

- In office work, salaries are by far the greatest employer cost, so even a small increase in productivity (due to an improved work environment) can provide a favorable return on investment;
- A speculative developer has little responsibility for indoor environment quality unless it is bad enough to result in litigation (i.e., there is a disconnect between a developer who assumes the development costs and an employer who obtains the benefits of long-term improvements in indoor environment quality);
- Health insurance costs are not directly tied to indoor environment quality even if illness can be linked to a poor indoor environment; and
- In residential settings, poor maintenance practices that often account for poor indoor environment quality are often found in low-income housing, where resources and motivation of the tenant or owner to correct problems are often lacking.

There is a need to convey the economic implications of improved practices and provide scientific evidence that intervention is effective. As an example, Mr. Fisk discussed economizer control module system technology, an energy-efficient approach that increases ventilation rates during mild weather to reduce the need for mechanical cooling. Economizer systems are rarely used in small office buildings and almost never in residential settings. It has been estimated that use of an economizer control module system could result in energy savings of approximately $26/person/year in the climate of Washington, DC. These estimates are usually used as a basis for determining whether the

energy savings (benefit) exceed technology cost. Frequently building professionals believe that the economic returns are insufficient. However, because economizers increase average ventilation rates, they can be shown to reduce levels of infectious airborne particles in the building and therefore could decrease respiratory illnesses. Mr. Fisk recommended that these systems be used more broadly. Calculations predict that sick-leave reductions worth approximately $200/person/year occur in addition to the energy savings. Mr. Fisk emphasized that developing and testing economic incentives for engineering health-protective buildings can provide a sound economic basis for investing much more in practices that assure good indoor environmental quality. He concluded with the following specific recommendations:

- Establishing lease and contract terms that reward indoor environment quality efforts;
- Rewarding facility managers of office and public housing properties for better indoor environment quality;
- Establishing a program of building labeling (analogous to EPA's Energy Star program) that allows consumers to recognize structures that have realized superior indoor environment quality in their design and construction;
- Tying HMO rates to indoor environmental quality protective practices of employers; and
- Linking professional liability insurance rates to indoor environmental quality training and practices.

Eileen Storey, M.D., M.P.H.
University of Connecticut Health Center

Dr. Eileen Storey expanded on general points made in her earlier presentation, using two ultimately successful case studies to illustrate how difficulties in initiating effective indoor environment air quality improvements in schools can be overcome. If administrators do not understand the health effects and risks involved, they may tend to stigmatize those reporting adverse health symptoms as disgruntled employees or overly "sensitive" individuals and dismiss the need for remediation. Alternatively, if those reporting problems are treated as "index cases," they can provide an opportunity to effectively address problems before they become too expensive to correct. Among the challenges to assessing the true risk is that carbon dioxide levels are often taken as a surrogate for effective air exchange, and no qualitative assessment is made of biological agents, which may have a great impact on health issues even when air exchange appears to be "adequate." The EPA's *Indoor Air Quality Tools for Schools* program has proved to be a very effective mechanism for identifying and correcting building problems in schools by establishing a building team directed toward applying relatively inexpensive solutions to IAQ problems. The same model could be applied to office buildings.

Some remediation efforts prove to be more successful than others. In her case studies, Dr. Storey indicated the complexity of issues that can arise. She first described a middle school in the Northeast, built in the 1950s with later additions. Staff and children were reporting a range of symptoms, including headaches. One teacher developed respiratory illness. Remediation of her classroom served as a starting point for more extensive

evaluation of building problems. Since time was needed to plan and fund systematic remediation, sensitive individuals were removed from the area. An engineer was hired to evaluate the building and to make recommendations. Survey results indicated that irritant and discomfort symptoms extended over a larger area of the school than the area where people were reporting acute respiratory symptoms. For financial reasons, remediation efforts began with the classroom in which the teacher developed respiratory illness. Carpeting was removed from the classroom, which introduced an additional problem because the underlying asbestos floor tile also had to be removed. A roof leak causing moldy partition and wet insulation problems above the deck was addressed initially by patching the leak and increasing ventilation under the roof, but these measures only enabled moldy air to spread through the school. The eventual solution, motivated in part by extensive public attention and involvement, required isolating and closing parts of the building while applying effective remediation measures sequentially. The multi-year remediation program included repeated staff and student health surveys and monitoring of air quality, with suitable measures to protect occupants during construction.

The second case was a late 19th-century Hartford, Connecticut, elementary school with a 15% asthma prevalence as compared the national prevalence of 5%. The building was heated by a centrally located boiler and the only ventilation was provided by windows. Water leakage linked to health problems for students and staff could be traced to primary structural problems, which were scheduled for needed repairs. In this school, the principal took a primary role in pushing the health improvement initiative using the *Tools for Schools* approach. Problem areas ("hot spots") identified on the basis of student and staff symptoms were the focus of systematic interventions. The effectiveness of the repairs was evaluated by closely monitoring the health of students before and after repairs were made. The principal stressed the role of the faculty in the prevention of asthma in their students. Dr. Storey indicated that this high level of involvement by the key school administrator was the major factor in the success of the program in this school.

Peyton A. Eggleston, M.D.
Johns Hopkins University

Dr. Peyton Eggleston discussed challenges facing those trying to reduce airborne allergens and toxins in inner-city areas, particularly as they affect the health of children. Respiratory morbidity can be seen as a consequence of a complex series of interacting factors. The primary causal sequence for asthma can be attributed to environmental allergens causing immunologic sensitization, resulting in asthmatic airway constriction. Secondary factors include toxic air pollutants that can affect general health status; susceptibility factors (inflammation, bronchial hyper-responsiveness); and underlying social factors (low income, stress, poor access to medical care, lack of education, etc.) that may impede both effective environmental solutions and medical treatment.

Results of the National Cooperative Inner City Asthma Study (NCICAS), conducted in eight urban centers in two stages (a cross-sectional study in 1992–1993 and a randomized intervention trial in 1994–1996) provided the primary basis for discussing environmental problems and impediments to their solution. Some of the problems in indoor

environmental quality can be related to the problems of low-income housing conditions, such as the following:

- Using a gas stove for heating in the winter (source of nitrogen oxides [NO_x]);
- Homes with windows painted shut, preventing their use for ventilation;
- Roofing that is poorly maintained by landlords, resulting in leakage;
- Occupied rental homes located next to abandoned row homes with severe water leakage and pest problems;
- Inadequate cash flow to permit proper maintenance and capital improvements; and
- Accumulation of trash in the home or nearby, encouraging pests and inhibiting effective pest extermination.

Many indoor air quality problems can be related to lifestyle characteristics that residents do not necessarily see as harmful, but which are contributing factors for asthma problems. For example, Dr. Eggleston indicated that the NCICAS study found that a cigarette smoker was a caregiver in 69% of the homes and that some significant contributions to indoor air particulates were a consequence of cultural preferences, such as burning incense. Other problems are a secondary effect of other social problems (e.g., neighborhood violence and drug dealing may keep children confined to the home for their safety, increasing their indoor environment exposure and reducing opportunities for outdoor exercise).

Hal Levin, B.Arch., ASHRAE Fellow
Building Ecology Research Group

Mr. Hal Levin discussed architectural and engineering performance standards that impact the design of healthier indoor environments. For the most part, there are few standards or agent limit values that can be applied to indoor environment pollutants. Only light levels, noise and acoustics, and temperature range are addressed in clearly established standards, although the California Division of Occupational Safety and Health (Cal/OSHA) has adopted moisture control regulations. Mr. Levin suggested that there is strong industry opposition to setting mandatory standards. In the current anti-regulatory political climate, adequate indoor environment regulations are unlikely in the near term. Building permitting is only partially effective for addressing indoor environment issues because it regulates only initial building design and construction, and has limited impact over the total life of the building.

To “fill the gaps” in indoor environment regulation (or guidance, in the absence of enforceable standards), it is necessary to establish concentration limits for indoor pollutants of concern and devise cost-effective methods for realizing them. Mr. Levin reported that indoor air experts agree that source control is more effective than dilution by increased ventilation rates. Although the quality of outdoor air used for ventilation can also be a factor, air filtering is typically limited to protection of mechanical and electronic equipment or to reduce housekeeping costs, not to improve health. In general, most buildings are “run blind” with respect to monitoring ventilation, indoor environment quality, and the effectiveness of air treatment technology. There is an absence of data

that can be used to evaluate products and services claiming to improve indoor air quality, such as portable air cleaners or duct cleaning services. A lack of clear standards also complicates evaluation of the effectiveness of any measures taken.

A comparison of symptom prevalence as a function of ventilation rate in building studies shows up to 10-fold variations in individual sensitivity at a given ventilation rate, as well as some general trends such as a gender difference (women generally showing higher sensitivity). There is no single "correct" ventilation rate for all buildings or for all individuals, and "applying conclusions from aggregated data obtained in multi-building studies can be hazardous to someone's health." Furthermore, in an era of increasing global energy use and cost and diminishing supplies, increasing ventilation will not be the preferred solution to indoor air pollution problems. Mr. Levin stressed the importance of diverse individual responses by designating the potency of an environmental agent as a function of "exposure" (defined as the product of concentration, time, and dose) and susceptibility factors (genetics, exposure history, health status, and age), which generally vary significantly in a population, often in unpredictable ways. There is inherent resistance in the building community to changing established building practices and techniques, or to making changes that might increase building costs. As a solution, Mr. Levin advocated taking an integrated or "ecological" approach, considering the full range of interdependent factors that produce the indoor "ecosystem," with an emphasis on formulating cooperative efforts to solving indoor environment problems.

James E. Woods, Ph.D., P.E, ASHRAE Fellow.
The Building Diagnostics Research Institute, Inc.

Dr. James Woods addressed the engineering challenges in ensuring healthy levels of performance from environmental control systems. Buildings are designed to provide safe, secure, and healthy conditions under both normal and extraordinary conditions. Standards and guidelines generally focus on safety or system performance issues, not on health protection or well-being of the occupants. Most codes and standards are enforced during design and construction stages, not during operations. Different categories of buildings have different requirements and issues. While most engineering interest centers on large public buildings (educational, health care facilities, office and mercantile, public assembly and worship – industrial buildings being excluded from this discussion), most buildings are small and most of our time is spent in residential and other small buildings.

Dr. Woods defined six barriers to improving building performance from a health standpoint:

1. The disaggregated history of building practice and reliance on established practices work against a consensus approach to introducing health-protective features and practices.
2. There is a lack of accountability for the health consequences of design and construction decisions; occupant health is often specifically excluded from contracts and is avoided in project documentation.
3. While there are little credible scientific data that relate exposures to health consequences, there are many speculative and anecdotal reports, making it

difficult to get clear cost/benefit information. Most available health data concern residential structures, and there is little information regarding commercial buildings. It is not easy to get cooperation to do such studies because of liability/litigation issues.

4. Misapplication of Value Engineering (VE) management practices to reduce first costs only (rather than achieve the long-term values realized by improved performance and beneficial health consequences) may increase occupant health and safety risks.
5. Deferred maintenance and other cost reduction policies (such as premature occupancy or occupancy during interventions) may increase health risks.
6. Liability and threat of litigation present major impediments to professionally attacking health issues; obtaining insurance to cover health issues or engineering to address health issues is extraordinarily costly, and many insurance policies have exclusion clauses for indoor environmental health issues.

Dr. Woods identified accountability as a key issue in making buildings healthier. He described the "healthy building cycle" (an approach similar to the life-cycle analysis approach), which is used by organizations such as the Healthy Building Network to evaluate environmental and health impacts of a material, building practice, or a service throughout its life cycle. In the cycle of addressing building problems (diagnosis, intervention, evaluation of the effectiveness in reaching a healthy building status), an accountable person must be identified who is empowered to ensure building performance and trained to know how to provide adequate performance and occupant protection in each phase in the building's life. In Dr. Woods' experience, 90% of problem buildings can be attributed to poor functioning of their control systems.

Questions and Comments

Many questions and comments followed these presentations. While most comments were in general agreement with the points outlined by the speakers, many reflected individual differences among participants as to how to weight priorities, assess the impact of different environmental agents, and promote research to provide a more solid scientific basis for action. Many advocated taking more precautionary actions based on limited indications of potential risk.

One environmental consultant commented on issues of route of exposure, suggesting that while indoor air quality issues are important, 60–80% of exposures are through non-inhalation routes of exposure such as hand contact. Mr. Levin stated that CDC has done work indicating the importance of skin absorption and hand-to-mouth transmission of pentachlorophenol in children, but that more still needs to be done. Mr. Fisk commented on building cleaning practices and how they can reduce exposures. For example, integrated pest management generally results in lower pesticide levels and reduced opportunity for contact exposure. Dr. Woods commented that health care facilities research suggests that half of nosocomial (hospital acquired) infections occur by contact and that cleaning practices are critical in reducing the rates.

Dr. Spengler raised the issue of conflicting practices, such as having fire code and security objectives that run counter to healthy indoor environment objectives. All implications of solutions for performance problems, such as energy conservation, must always be considered. Dr. Woods suggested that a bigger problem is legacy construction, meaning that any innovations, no matter how good, will take some time to affect the health of a majority of the population. He estimated that 80% of existing buildings will still be in use 20 years from now.

Mr. Levin commented that the EPA's *Indoor Air Quality Tools for Schools* material is a model for what can be done to inform individuals on how to improve their home environment. Mr. Fisk mentioned Finland's outreach program discussed at the Healthy Building 2000 Conference. Several participants emphasized the need to educate the public on practices that can improve indoor environment quality rather than waiting for more definitive research information to establish stronger cost-benefit arguments. Dr. Eggleston pointed out that low-income-housing residents have limited ability to resolve issues such as roof leaks and that the landlord population can be a particularly tough group to motivate and educate. A federal legislative aide in the audience discussed a pending toxic mold bill (there have been several in previous legislative sessions and a number of state bills have passed) and stressed the public health needs conveyed to him by individuals describing their personal health problems. He suggested that the scientific community work with legislators to address the issue. A participant indicated that the National Academy of Sciences' (NAS) Institute of Medicine (IOM) report, *Damp Indoor Spaces and Health* (2004), conveyed the impression that mold problems are not so serious. Others stated that the report had identified the problem clearly, and suggested that the alternative view is perhaps a misunderstanding based on the type of cautious language scientists use when dealing with possibly causal associations that are not firmly established (see the following section for more discussion on this report).

Several participants discussed the economic impact of health problems attributable to poor indoor environment quality and how to motivate health payers to take a more active role in effecting changes. Some HMOs and employee health providers are ready to invest in an environmental approach, but some still need a business plan to persuade them it is in their best long-term interests to do so. Some participants mentioned that the economic impact of health problems attributable to poor indoor environment could support this kind of intervention for Medicare patients.

Some participants suggested that proof for the effectiveness of environmental measures seems to be held to a higher standard than that used for medical interventions. This resulted in considerable back-and-forth discussion on the limited ability of intervention research to provide convincing data supporting the cost-effectiveness of environmental intervention in solving health issues. It was also mentioned that there is a high cost to conducting good field studies that are sufficiently large enough to generalize the results for policy decisions and that there are few sources of funding available for these types of interventional studies.

Highlights from Challenges to Bringing about Health-Promoting Changes in Indoor Environments Session

Non-inhalation routes of exposure to indoor contaminants can be just as important as inhalation.

Some health problems associated with the indoor environment can be related to the problems of low-income housing conditions.

The lack of comprehensive standards for indoor environmental criteria, especially for indoor air pollutant concentrations, is a barrier to establishing standards for healthy building materials, ventilation, and other critical factors.

Building professionals are generally isolated from the consequences of decisions that result in suboptimal indoor environment quality.

Applying market forces by demonstrating favorable cost-benefit ratios requires better data on health and productivity benefits that result from specific measures to improve indoor environment quality.

Current market forces are heavily weighted toward initial costs, whereas making buildings more health-protective requires good practices through the entire building life cycle.

A significant portion of existing buildings will still be in use 20 years or more from now. Healthy indoor environment activities will need to address both existing and new building issues.

There is a need to convey the economic implications of improving the indoor environment and of ignoring indoor environment problems, and to provide scientific evidence that intervention is effective.