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Energy-Efficiency Programs and Indoor Air Quality

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Introduction:

Energy efficiency is regarded as an attractive short- and medium-term strategy to address climate change and other environmental impacts from the use of conventional fuels. For example, in order to stabilize CO2 emissions in year 2000 at current levels, up to 75% of the reductions may need to be derived from energy efficiency (1,2).

Although the causes of indoor environment problems are broad and complex, they are often blamed on energy conservation even though energy efficiency (EE) technologies can often be solutions to problems. This link threatens to limit EE opportunities and may even result in increased energy consumption as owners and companies try to solve problems through increased ventilation.

Concerns about indoor air quality have already resulted in the development of new ventilation standards with higher rates of ventilation. The revised ASHRAE ventilation standard (3) will triple the minimum ventilation rates in offices. This could increase overall HVAC loads by 5-20% in the absence of additional EE measures (4). A similar situation exists for new housing where a proposal to reference CSA Standard F326 (5) in the National Building Code could result in increased energy consumption in the absence of additional EE measures. Since the population appears to be becoming more sensitive to contaminants, additional demands for better indoor and outdoor environments could result in further increases in energy consumption.

Indoor Environment Issues:

To assure a satisfactory indoor environment, a building must have proper space layout, thermal comfort, high acoustical/noise performance, good indoor air quality and high visual/lighting quality. A total indoor environment approach is required. Indoor air quality (IAQ) is the highest priority but it is not the only issue.

Sources of potentially harmful air pollutants include heating and cooling systems, combustion appliances, personal use products, furnishings of all types, tobacco products, outside pollutants and soil gases, cleaning and maintenance products and bioeffluent from humans and animals. Microbial contamination such as toxins from mould is a growing concern as well as volatile organic compounds (VOCs). Generally these problems can be managed by removing or controlling harmful sources; ventilating with fresh air; controlling building pressure differentials; and, filtering air to remove substances.

Many problems are linked to poor ventilation system design, operation and maintenance. These include: poor air circulation and distribution; inadequate outdoor air supply; leakage of humid air into walls and ceilings; poor temperature or humidity control; spillage of combustion gases into buildings; outdoor contamination from the reentry of building exhaust and motor vehicle exhaust from garages and loading docks; chemical contamination from copy machines, tobacco smoke and buildings materials; and, biological contamination from poor maintenance, dirty filters, malfunctioning humidifiers and excess moisture.

Therefore, good indoor environments are dependent on addressing the interaction of many systems within buildings, their operation and maintenance. Ignoring or neglecting these interactions can result in uncomfortable space conditions and occupant complaints. This requires a multi-disciplinary approach involving researchers, engineers, designers and occupants yet the building industry is structured with a high degree of specialization.

IAQ Related Programs:

Since 1980, ventilation and indoor air quality have been priorities for federal agencies such as Energy, Mines and Resources Canada (EMR), Canada Mortgage and Housing Corporation (CMHC), the National Research Council (NRC) and Public Works Canada (PWC); provincial ministries of energy and housing; utilities; and, industry organizations such as the Canadian Home Builders' Association (CHBA). A wide range of activities have been undertaken in areas such as air infiltration and exfiltration, ventilation, combustion spillage and indoor air quality.

The R-2000 Home Program is one of the best examples of how energy efficiency through controlling air infiltration can be achieved while maintaining good indoor air quality. Established in 1982 by EMR in cooperation with CHBA, the goal of the program is to construct safe, comfortable and affordable energy-efficient houses with indoor environments that were comparable or superior to those found in conventional houses.

R-2000 houses must have continuously operating mechanical ventilation systems that distribute outside air to all habitable rooms and exhaust air from high pollutant sources such as kitchens and bathrooms. The houses must have an airtightness level under 1.5 ACH at 50 Pascals. Houses must be built by builders who have attended special training courses. Naturally aspirating combustion appliances are not allowed in R-2000 homes due to the possibility of venting failure.

The program's IAQ related activities involve a wide range of activities including technology development, standards development, industry training programs and consumer awareness. The program deals with quality assurance issues and implemented an extensive monitoring program (6). The program did not function in a vacuum, other groups and agencies worked with and complemented the efforts of the R-2000 Program.

The Flair Homes Project is one notable example involving twenty R-2000 homes of similar design which that used using different techniques to achieve energy-efficiency and comfortable environments with good air quality (7).

The Advanced Houses Program is part of the federal government's commitment to the environment under the Green Plan (8). In cooperation with CHBA and private/public sector sponsors, the program promotes innovation and advances the state of the art of residential housing in Canada through the construction, demonstration and monitoring of ten Advanced Houses across Canada. Successful new concepts will be considered for integration in an updated R-2000 technical standard.

Advanced Houses are being built to stringent technical requirements (9). They should use 25% or less of the energy consumed by conventionally built homes for space heating and cooling, domestic water heating, appliances and lighting, and outdoor electric usage. Advanced Houses must meet stiff guidelines for indoor air quality, noise levels, and humidity. They must also meet tough new environmental requirements for water usage (50% reduction), recycling, the use of recycled materials, and provide a construction waste management plan.

C-2000 Advanced Commercial Buildings Program (10) is a new pilot program to encourage the construction of a small number of very high-performance commercial buildings. The program, being developed by CANMET (Canada Centre for Mineral and Energy Technology), is also part of Canada's Green Plan activities. It will provide an opportunity for innovative architects, engineers, contractors and developers to play a major role in the development of high-performance buildings that will influence the next generation of commercial buildings.

C-2000 is more than an energy efficiency program: it will demand exceptional indoor environment for occupants, high levels of functional performance and minimal adverse environmental impacts over the life of commercial buildings. This whole-building performance approach is based on CANMET's experience that energy and environmental agenda can be most effectively adopted by the industry if an integrated systems approach is taken.

A relatively unique aspect of the program is that the high level of performance will have to be maintained over the life of the building. On-going monitoring will ensure that performance levels are being maintained in buildings that wish to retain their C-2000 status. The development of management plans, the training of building operators and the long-term participation of tenants in the operation of buildings will therefore be important features of C-2000 projects.

The initial approach is to focus on office and multi-unit residential buildings of less than 150,000 square feet but in recent discussions with a national fast-food chain and with a national retail chain indicate that pilot projects for these building types offers great potential and we are now considering the inclusion of these building types in the program.

CMHC has also been very active (11) and recently initiated a Healthy Buildings Design Competition (12) to provide a vision of sustainable housing that takes into account environmental, economic and social dimensions where "healthy housing" refers to housing which is healthy both for the occupants and for the global environment.

The design competition strives to address a wide range of issues including healthy indoor environments (improved IAQ, lighting, acoustics and spatial aesthetics); optimum use of interior space & building sites, reduced operating, peak and embodied energy; reduced water consumption, use of environmentally benign materials; and, reduced construction and domestic waste. A range of approaches are being investigated for urban and suburban situations; new, infill and retrofitted homes; and, single and multiple dwellings.

Various federal government agencies have also been active in IAQ and ventilation R&D activities funded by the Panel on Energy R&D (13). Activities include ventilation standards, spillage from combustion appliances, emissions from materials and predictions of indoor exposure, and moisture and ventilation assessment procedures have also been developed to identify potential problems when houses are being retrofitted (14).

Activities also include participation in International Energy Agency (IEA) activities including the Air Infiltration and Ventilation Center (Annex 5), airflow patterns in buildings (Annex 20 & 24), demand controlled ventilation (Annex 18) and multi-zone airflow modelling (Annex 23).

Technology transfer activities have been wide ranging including support the development of training manuals for industry(ref), conferences and seminars (Indoor Air 90, NATO Pilot Study on Indoor Air Quality and the 5th International Jacques Cartier Conference.

Conclusions:

Current energy-efficiency programs place great importance on providing an excellent indoor environment. Programs have not only focused on research but field trials, standards development, technology transfer to industry and consumer information.

This work has led to significant changes to way buildings are constructed and operated in Canada. This has resulted in the evolution of low-energy buildings that are both energy-efficient and have good indoor air quality. EE measures must not compromise but enhance the indoor environment. Indeed, individuals with environmental sensitivities are using R-2000 construction techniques as the basis for the construction of "clean" homes using low-emission products.

The success of programs such as R-2000 Homes is due to an orderly process and integrated set of activities that respond to a construction philosophy recognizing buildings as system. It requires a cooperative, integrated process of research and development, demonstration and monitoring, education and regulation initiatives.

A "systems" approach needs to be taken to address the complex interactions between many different sub-systems and to ensure that individual measures are not counter-productive and address issues such as indoor air quality, comfort, security and durability.

Better and more integrated ventilation systems still need to be incorporated in buildings. A high priority should be placed on developing those systems that incorporate waste heat recovery, distribute ventilation air more effectively, provide greater occupant control and are relatively easy to commission and maintain. Future construction will stress the need to ensure the well-being of occupants.

For CANMET's Buildings Group, the Advanced Houses Program and the C-2000 Advanced Commercial Buildings Program will be a key focal points for these activities.

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