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Air Tightening New Houses For Improved Energy Efficiency - What Is The Potential?

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In the last ten years, construction practice has evolved in response to the need for reducing air leakage through the building envelope of houses. As a result, new houses are being built more airtight. Recognizing this fact, the 1990 National Building Code (NBC) requires a mechanical ventilation system capable of producing 0.3 air changes per hour, thus providing a mechanical means of achieving minimum ventilation levels when needed. With only a few regional exceptions, builders have been meeting the intent of the mechanical ventilation provisions of the NBC with exhaust-only fans - typically kitchen and bathroom fan combinations.

Given these developments in NBC requirements, recent trends in house design, and the need to achieve energy efficient construction, the following questions arise:

* How energy efficient is current house construction with respect to overall air change?
* Can we achieve additional energy efficiency, without compromising minimum ventilation requirements?

As the debate on getting the right balance between airtightness, ventilation, energy cost, and first cost of a house has been going on for some time in Canada, most readers will have an opinion - and likely a strong one - on how the questions should be answered.

Those who argue that houses are already being built tight enough refer to improvements in building practice in recent years, increasing occupant complaints relating to indoor air quality and the offsetting energy costs of operating fans for additional ventilation over a greater proportion of the time. Those who argue that even tighter envelopes are needed cite the success of the R2000 approach which controls excessive air leakage during cold or windy periods with a tight envelope, provides better air quality through a controllable mechanical supply of fresh air and saves energy with heat recovery ventilation, thus offsetting higher first costs.

The arguments are compelling on both sides, in part because each can be right for different circumstances - conditions that vary throughout the heating season and from location to location. In cold and windy weather a tighter envelope reduces cold drafts and excessive heat loss, as well as condensation within the construction. In moderate winter conditions, the appeal of a 'passive' ventilation system, i.e., air leakage that delivers adequate fresh air at no additional cost has some attraction. What really can't be determined through general debate is the degree to which each of these conditions persist throughout the heating season.

In an attempt to provide quantitative information on the subject, the Institute for Research in Construction (IRC) undertook an investigation to determine the range and distribution of conditions and air change rates experienced by typical new houses in various locations across Canada. The 1989 cross Canada survey of airtightness levels in 200 new tract-built houses provided some of the information needed. A computer-based simulation model of infiltration and ventilation, developed at IRC, was used to investigate air leakage rates for typical ranges of airtightness levels and weather conditions found across Canada.

The study results indicated that leaky houses often experience excessive air leakage during a significant part of the heating season. For example, a leaky house in a cold prairie climate (leaky by today's standards, with a normalized leakage area, NLA* = 2.1) might have air leakage rates of 0.4 air changes or more per hour for up to 1500 hours or 30% of the heating season. These high air leakage rates occur during the coldest winter weather. For most occupancies, this level of air leakage could be uncomfortable and expensive to heat. On the other hand, this house would have low air change rates (e.g., 0.2 air changes per hour or less) only 20% of the time - generally in calm and mild weather. For this house, providing additional ventilation during these calm periods would be a trivial task, easily addressed by a manual-control exhaust-only fan system, or opened windows.

The airtightness survey results indicate that most new houses today are not as leaky as previously thought, especially in the prairie provinces. For example, a house with an NLA of 1.5 cm^2/m^2, i.e., 30% tighter than the house in the above example, would still be leakier than the average new market house in Winnipeg. Such a house would not experience excessive air change over the heating season (no occurrences of 0.4 air changes per hour or more). However, the tighter house's occurrence of low natural air change (0.2 or less) would increase to 70% of the time. Depending on occu-

* The normalized leakage area, NLA, is a measure of envelope leakiness, as determined by a standard airtightness test. 1.5 cm^2/m^2 was the average for houses in the 1989 survey; In some areas (such as coastal B.C.) houses are much leakier. 0.7 cm^2/m^2 is the R-2000 limit.

pancy needs, mechanical ventilation could be needed more often. This pattern of results was found for houses surveyed right across Canada, with the exception of Vancouver houses which were found to be generally leakier.

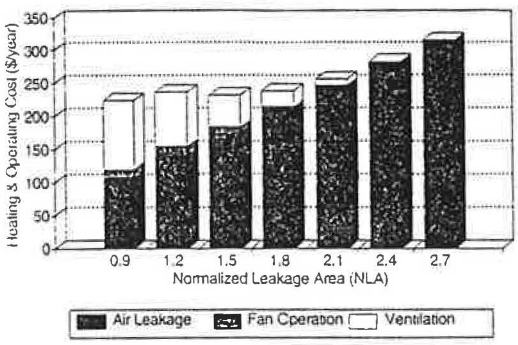
The analysis was extended to calculate the total energy costs of air leakage and exhaust-only ventilation over the heating season. This is difficult to simulate with confidence because the actual ventilation needs of a given household are not constant, varying with the comings and goings of the occupants and their activities in the home.

For this study, the following scenario was assumed: a family of three living in an average size house would require at least 0.25 air changes per hour (ach) when all were at home during the evening and overnight, and at least 0.1 ach when only one person was present during the day. These levels were not based on any standard requirements nor was consideration given to the effect of indoor contaminant emissions from sources such as construction materials and sealants .

For simulation purposes, when air change rates due to air leakage fall below these arbitrary minimums, one or two exhaust fans are turned on as needed. The computer program keeps track of all fan operations and ventilation flow rates, as well as the associated energy and dollar costs of each.

As would be expected, as the house gets tighter, the cost of additional ventilation using exhaust-only fans goes up while the energy costs associated with envelope leakage goes down. However, these two opposing effects start to balance out at the leakier end of the spectrum of today's construction; i.e., the total energy cost remains essentially constant and the energy savings are much reduced or nil for envelopes with NLA's below the thresholds identified for each location.

Cost of Air Leakage & Ventilation
Winnipeg Example: Gas Heating (1990 Dollars)



For example, in Winnipeg the threshold NLA was 1.5 cm^2/m^2 (see figure). This suggests that if the assumptions for fresh air requirements used in our analysis are reasonable, it could be concluded that the majority of builders' homes surveyed that had exhaust-only systems have achieved the energy balance between envelope tightness and ventilation.

As air sealing techniques become more effective (a trend that should continue for improved quality, durability and comfort), builders should consider more sophisticated ventilation systems such as low-flow continuous systems, heat recovery ventilators, or automatically controlled systems; e.g. demand-control ventilation. The effectiveness of these options should be investigated for various levels of envelope airtightness. It's becoming clear that if additional energy efficiency or air quality is sought in new construction, more stress on the ventilation side is needed, as the tighter the building envelope becomes, it is mechanical ventilation - not air leakage - that becomes the dominant energy loss component of air change.

The electricity cost of running ventilation fans was estimated to be less than 10% of the total cost of air change, even when run continuously, and even in locations where cheaper natural gas is used for space heating.

To answer the questions posed at the beginning of this article, it appears that most new homes are quite efficient relative to what can be achieved with manually controlled exhaust-only systems. Further air tightening without consideration for more efficient mechanical ventilation may not save more energy. The dilemma is that the quantities of energy involved in air change are still substantial - easily one third of the total energy bill of a typical new house. This suggests that further opportunities for improving energy efficiency for the air change component of new houses would be found in more efficient ventilation systems.

A shift to better planned ventilation appears to be happening already in many parts of the country, and codes and standards are currently being reviewed to reflect these trends. With more efficient ventilation systems in place, the feasibility of further envelope tightening will depend on the costs and benefits of the overall tightening/ventilation strategy. Finally, there is a need to encourage the universal adoption of good air barrier practices in order to eliminate those few remaining leaky houses still being built.

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