NRC Publications Archive Archives des publications du CNRC

Air tightening new houses for improved energy efficiency: What is the potential?

Swinton, M. C.; Reardon, J. T.

This publication could be one of several versions: author's original, accepted manuscript or the publisher's version. /
La version de cette publication peut être l'une des suivantes : la version prépublication de l'auteur, la version acceptée du manuscrit ou la version de l'éditeur.

Publisher's version / Version de l'éditeur:

Journal of Thermal Insulation and Building Envelopes, 16, Jan, pp. 222-226, 1993-01

NRC Publications Record / Notice d'Archives des publications de CNRC:

<https://nrc-publications.canada.ca/eng/view/object/?id=ae73d8c8-d2e0-46c4-9884-4d5dc66dba4b>
<https://publications-cnrc.canada.ca/fra/voir/objet/?id=ae73d8c8-d2e0-46c4-9884-4d5dc66dba4b>

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at

<https://nrc-publications.canada.ca/eng/copyright>

READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site

<https://publications-cnrc.canada.ca/fra/droits>

LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at

PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

National Research
Council Canada

Conseil national de
recherches Canada

Canada

<http://www.nrc-cnrc.gc.ca/irc>

Air tightening new houses for improved energy efficiency: What is the potential?

NRCC-36025

Swinton, M.C.; Reardon, J.T.

January 1993

A version of this document is published in / Une version de ce document se trouve dans:
Journal of Thermal Insulation and Building Envelopes, 16, (Jan), pp. 222-226,
January-93

The material in this document is covered by the provisions of the Copyright Act, by Canadian laws, policies, regulations and international agreements. Such provisions serve to identify the information source and, in specific instances, to prohibit reproduction of materials without written permission. For more information visit <http://laws.justice.gc.ca/en/showtdm/cs/C-42>

Les renseignements dans ce document sont protégés par la Loi sur le droit d'auteur, par les lois, les politiques et les règlements du Canada et des accords internationaux. Ces dispositions permettent d'identifier la source de l'information et, dans certains cas, d'interdire la copie de documents sans permission écrite. Pour obtenir de plus amples renseignements : <http://lois.justice.gc.ca/fr/showtdm/cs/C-42>

National Research
Council Canada

Conseil national
de recherches Canada

Canada

Air Tightening New Houses for Improved Energy Efficiency— What Is the Potential?*

MICHAEL C. SWINTON AND JAMES T. REARDON

*Institute for Research in Construction
National Research Council of Canada*

IN THE LAST decade, construction practice has evolved in response to the need for reducing air leakage through the envelopes of houses. As a result, new houses have been built more nearly airtight on average. In recognition of this fact, the 1990 National Building Code (NBC) requires a mechanical ventilation system capable of producing 0.3 air changes per hour, thereby providing a mechanical means of achieving minimum levels of ventilation 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 and 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?
- What is the feasibility of further tightening of envelopes to achieve additional energy efficiency, without compromising minimum ventilation requirements?

Since the debate on achieving 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 above questions should be answered. Those who argue that houses are currently being built tight enough cite improvements in

*This article first appeared in *Solplan Reviews*, December-January, 1993.

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 time. Those who argue that tighter envelopes are needed cite the success of the R2000 approach, which controls excessive air leakage during cold or windy periods with a tighter envelope, provides better air quality through a controllable mechanical supply of fresh air, and saves additional energy with heat recovery ventilation, thereby offsetting higher first costs. The arguments are compelling on both sides, in part because each side can be right for different conditions—conditions that vary throughout the heating season and from one location to the next. In cold and windy conditions, a tighter envelope is a welcome feature that reduces cold drafts and excessive heat loss, not to mention interstitial condensation. Yet in moderate winter conditions, the appeal of a “passive” ventilation system, i.e., air leakage that delivers adequate fresh air at no additional cost, retains some appeal. 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 analysis results indicated that houses at the leakier end of the spectrum often experience excessive air leakage during a considerable part of the heating season. For example, a relatively leaky house in a typical cold prairie climate (leaky by today’s standards, with a normalized leakage area, $NLA^{**} = 2.1$) might experience air leakage rates of 0.4 air changes or more per hour for up to 1500 hours or 30% of the heating season. To compound the energy issue, these high air leakage rates occur during the coldest winter conditions. For most occupancies, this level of air leakage could be uncomfortable and expensive to heat. On the other hand, this house would experience 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,

******The normalized leakage area, NLA, is a measure of envelope leakiness as determined by a standard airtightness test. $1.5 \text{ cm}^2/\text{m}^2$ was the average for houses in the 1989 survey.

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 $1.5 \text{ cm}^2/\text{m}^2$, i.e., 30% tighter than the house in the above example, would still be leakier than the average surveyed for the Winnipeg sample in 1989. 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 houses' occurrence of low natural air change (0.2 or less) would increase to 70% of the time. Depending on occupancy needs, mechanical ventilation could be needed more often. This pattern of results was found for houses surveyed right across Canada, with the exception of the 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 seldom constant, varying with the comings and goings of the occupants and their activities in the home. For this investigation, 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, when the envelope 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 constructions; i.e., the total energy cost remains essentially constant and the energy savings much reduced or nil for envelopes with NLAs below the thresholds identified for each location. For example, in Winnipeg, the threshold NLA was $1.5 \text{ cm}^2/\text{m}^2$ (see Figure 1). This suggests that if the assumptions for fresh air requirements used in our analysis are reasonable, it could be concluded that the majority of surveyed builders of homes with exhaust-only systems achieved the energy balance between envelope tightness and ventilation.

As tightening techniques become more effective (a trend that should continue for improved quality, durability and comfort), builders should con-

FIGURE 1. Cost of air leakage and ventilation. Winnipeg example: gas heating, \$1990.

sider 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 focus on the ventilation side is needed, since, for the tighter envelopes found in the survey, mechanical ventilation—not air leakage—is estimated to be the dominant energy loss component of air change. As a point of interest, 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 does appear that most of the surveyed new homes were quite efficient relative to what can be achieved with manually controlled exhaust-only systems. Further air tightening without due 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 house built today. 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.