

**AIRTIGHTNESS AND ENERGY EFFICIENCY
OF NEW CONVENTIONAL AND R-2000
HOUSING IN CANADA, 1997**

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EXECUTIVE SUMMARY

Natural Resources Canada (NRCan), in cooperation with Canada Mortgage and Housing (CMHC) and the National Research Council of Canada (NRC), has undertaken a national survey of the airtightness and energy efficiency of new housing, including both conventional and R-2000 houses in all southern regions of Canada. The Canadian Home Builders' Association (CHBA) was instrumental in the selection of typical conventional merchant built housing which makes the survey representative. Additional data was received from Hydro-Québec, Centra Gas, Manitoba Hydro and B.C. Hydro.

Canada is a world leader in cold climate housing. The Canadian emphasis on increasing airtightness has led to increased energy efficiency, reduced house moisture damage, and improved comfort. These benefits can be achieved, without causing indoor air quality (IAQ) problems due to inadequate ventilation or depressurization and spillage, by improving ventilation equipment and installing depressurization tolerant combustion appliances.

The database for this study consists of detailed information on 163 new conventional houses and 63 R-2000 houses. The new conventional houses were built in 1990 through 1996 and have an average volume of 652 m³, and the R-2000 houses were built in 1983 through 1995 and have an average volume of 792 m³, or 22% larger. The airtightness results from this database are compared with historical trends from a survey of 2,037 houses built from 1793 through 1996.

Airtightness is analyzed in various ways, and shows a general, ongoing trend to more airtight houses with significant but decreasing regional differences, as shown in Figure S1. Although R-2000 houses continue to be significantly tighter and more efficient than new

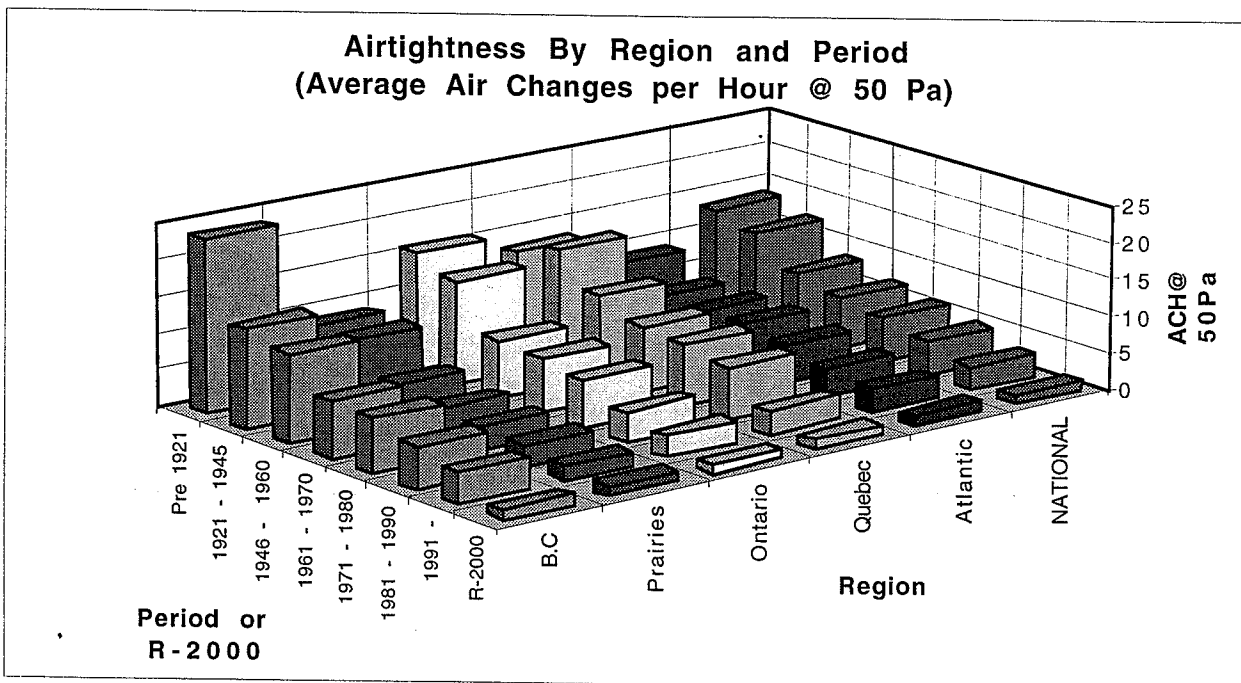


Figure S1. Average Airtightness (Air Changes per Hour @ 50 Pascals) by Region and Period, with R-2000 Houses for Comparison.

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conventional houses, the gap is narrowing. Conventional houses built from 1990 to 1996 are thirty-five percent tighter than those built from 1985 to 1989.

Greater airtightness creates a need for mechanical ventilation in order to avoid potential IAQ problems. This study shows that many of the new conventional houses are airtight enough to require mechanical ventilation to minimize IAQ problems, but have no central mechanical ventilation systems. These houses must rely solely on kitchen and bathroom fans which are seldom run continuously. See Table S1. R-2000 houses are all very airtight, but have heat recovery ventilators (HRVs) which are adequately sized to provide sufficient fresh air if run continuously.

Region	Number of Houses	Natural Air Change Rates (ach)			House with Natural ach less than:			
		Min	Mean	Max	<0.35	<0.20	No Mech. Vent. <0.35	<0.20
B.C.	12	0.015	0.153	0.390	92%	75%	83%	67%
Prairies	69	0.017	0.156	0.426	97%	68%	22%	13%
Ontario	20	0.063	0.221	0.452	85%	55%	45%	25%
Quebec	30	0.059	0.226	0.605	80%	50%	67%	40%
Atlantic	24	0.060	0.212	0.496	83%	63%	0%	0%
National	155	0.015	0.186	0.605	90%	63%	35%	22%

Table S1. The natural air change rates, and potentials for IAQ problems, of new conventional houses.

Airtight houses are also subject to depressurization which can lead to spillage of combustion products from fuel burning equipment. This occurs when exhaust fans cause the air pressure inside the house to be lower than outside. Then, the combustion gases from furnaces and hot water heaters can be spilled into the house instead of up the flue, causing potentially serious IAQ problems. For houses with spillage susceptible appliances the maximum allowable house depressurization is 5 Pascals (Pa). Up to 40% of spillage-susceptible new conventional houses are subject to depressurization of greater than 5 Pa, as shown in Figure S2. R-2000 houses do not have potential depressurization problems because they always have balanced ventilation, and, if required, have make-up air for any spillage-susceptible devices.

The energy efficiency of new conventional and R-2000 houses is examined both in terms of space heat energy, and by the newly developed energy rating system of EnerGuide for Houses. There are significant differences in energy efficiency between new conventional and R-2000 houses, and there are some significant regional variations. Based on the datasets, new conventional houses consume an average of 93 giga-Joules per year (GJ/y) for space heating, and this figure varies from 56 in Quebec to 119 in the Prairies. By comparison, R-2000 houses consume 70 GJ/year which is 25% less than new conventional houses, and which varies from 41 in Quebec to 101 in the Prairies. Larger houses consume more energy than smaller ones, and the

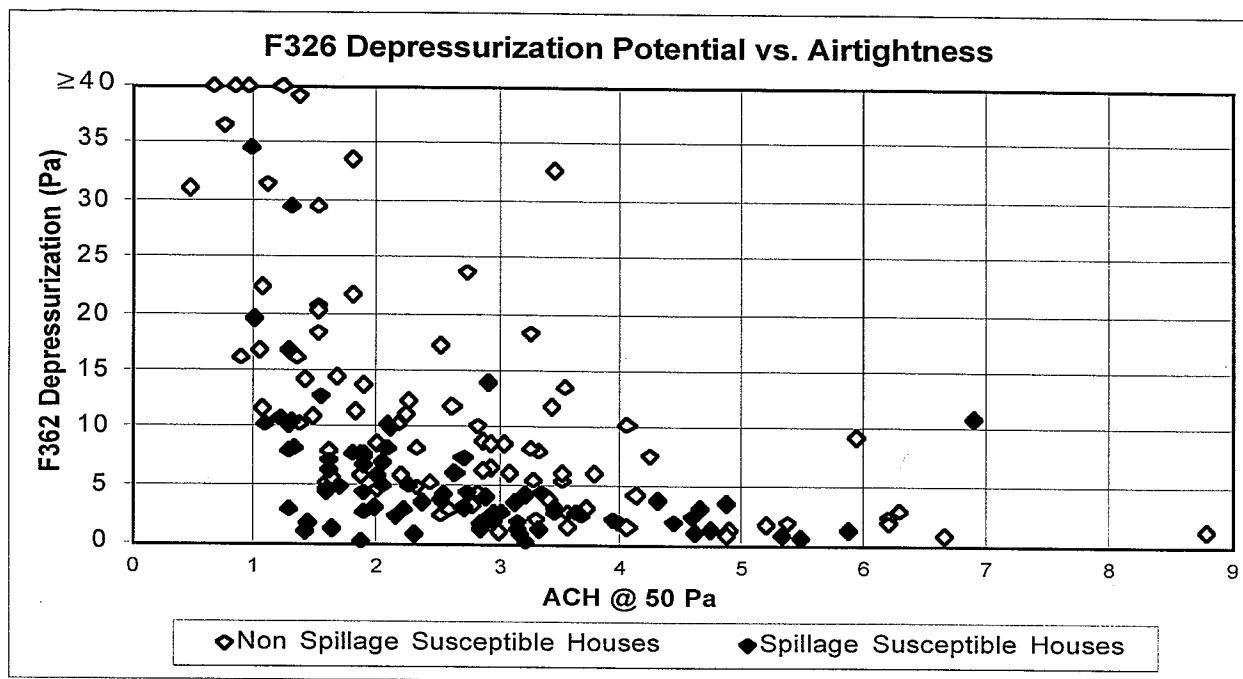


Figure S2. Depressurization Potential vs. Airtightness.

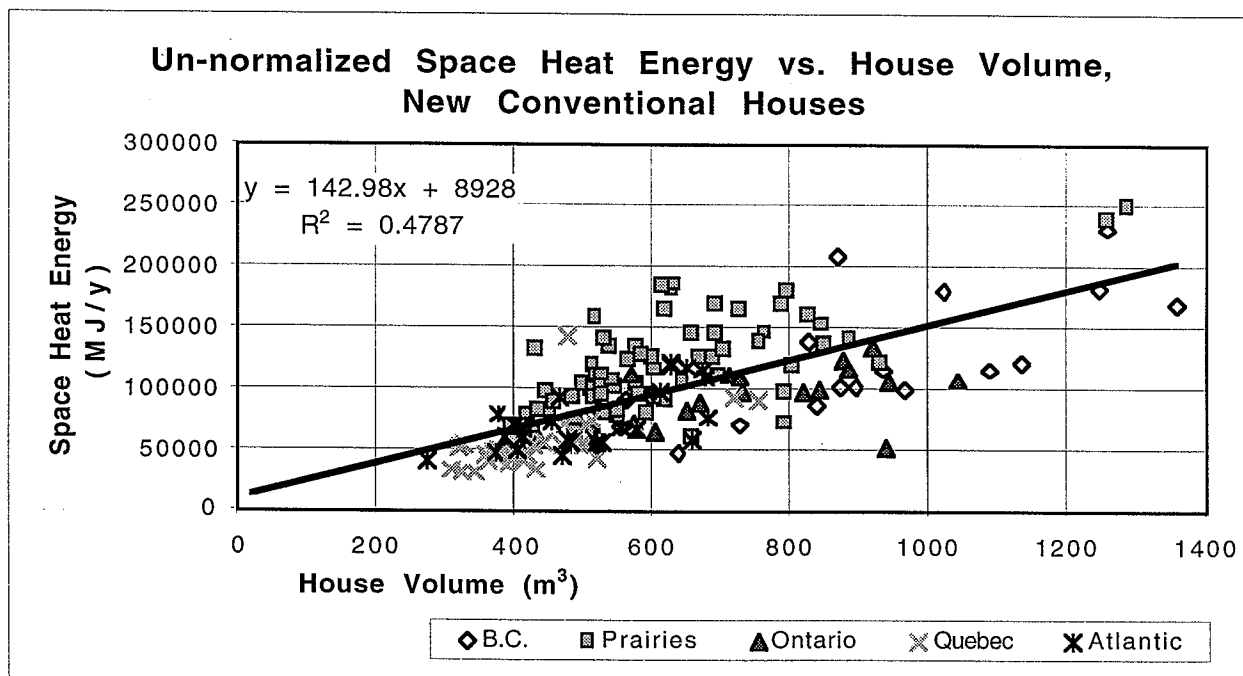


Figure S3: Un-normalized space heat vs. house volume, new conventional houses.

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relationship is roughly linear as shown in Figure S3. When normalized by size, and by climate and fuel efficiency, the R-2000 advantage increases to 33%

The EnerGuide for Houses program is a method of rating the energy efficiency of houses normalized by size, climate and fuel efficiency. Because it normalizes energy use by volume it allows large houses which use large amounts of total energy to receive equal ratings with smaller houses which use less total energy. Given the trend toward larger houses with fewer occupants, even significant improvements in the EnerGuide ratings for houses may not result in less energy use for housing. Under the EnerGuide for Houses energy efficiency ratings, new conventional houses average 73 out of 100, and R-2000 houses have an average rating of 79; regional variations are shown in Figure S4.

Figure S5 shows where heat is lost from new conventional and R-2000 houses. The columns show the average amounts of heat lost through the sections of the house envelopes and by natural and mechanical ventilation. It is interesting to note that R-2000 houses lose more heat through windows than conventional houses do, due to their larger size and window area. The largest difference occurs in the basements where new conventional houses lose 38% more heat than R-2000s despite their smaller size. A comparison of the most and least energy efficient new conventional houses shows that the greatest difference between them is in basement heat losses;

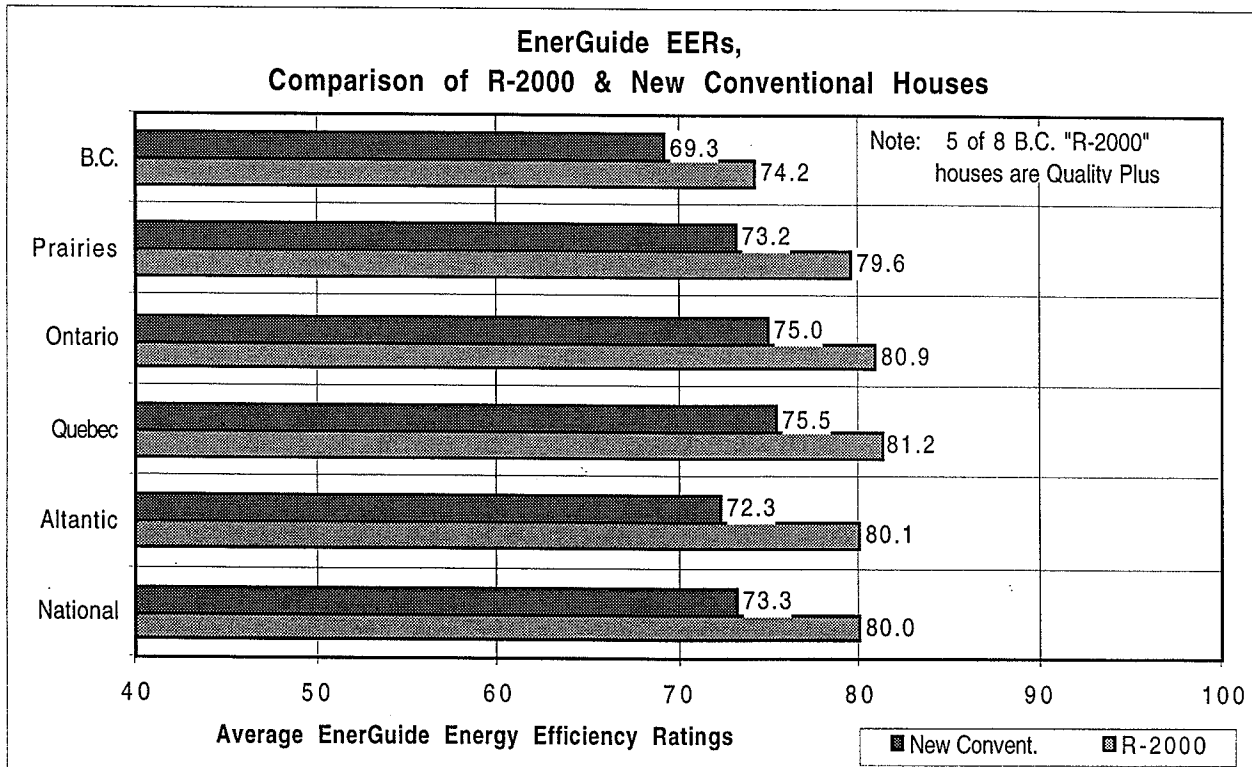


Figure S4. Average EnerGuide for Houses Ratings of New Conventional & R-2000 Houses.

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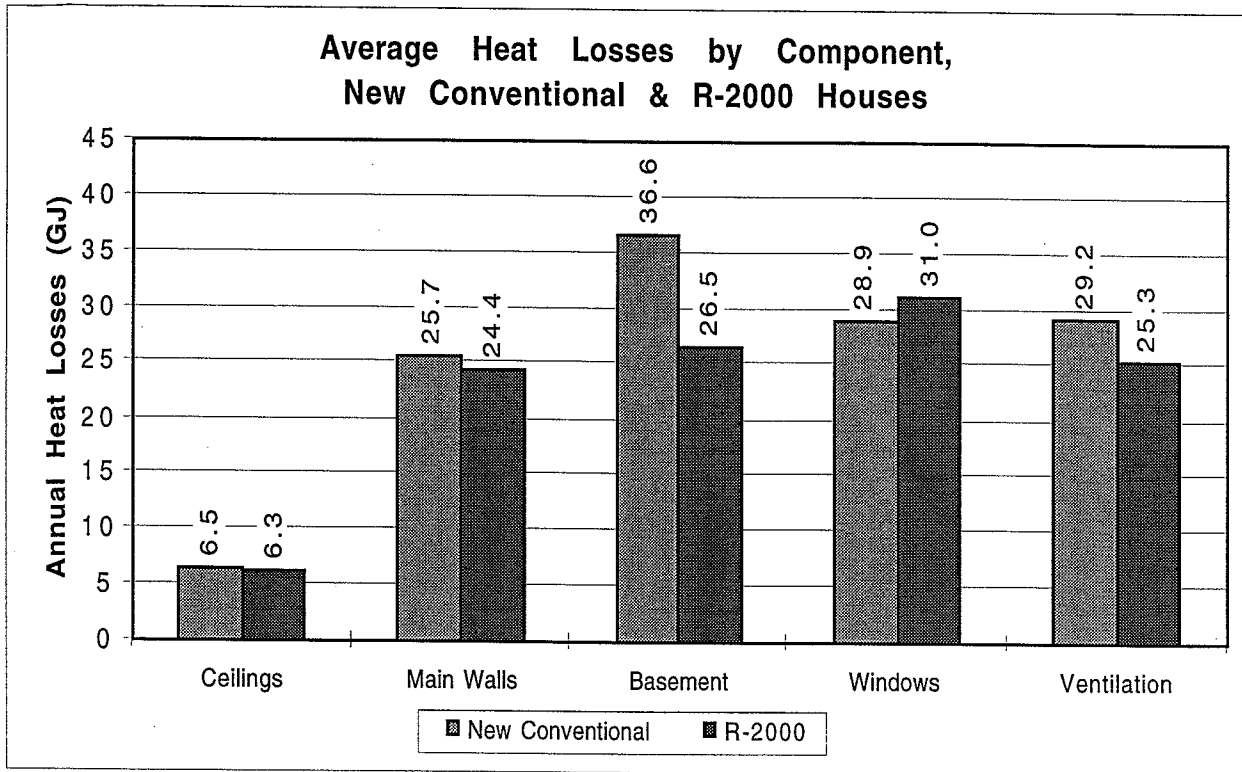


Figure S5. Average heat losses by component, new conventional and R-2000 houses.

the least efficient 10% of new conventional houses lose over 40% of their heat through their basements while the most efficient lose about 27% through their basements. These results indicate that greater attention should be given to basement insulation.

Canadian houses continue to become more airtight and energy efficient. R-2000 houses are still significantly tighter and more efficient than new conventional houses, but the gap is narrowing. Increased airtightness does create potential IAQ problems, but these can be dealt with by ventilation and combustion equipment installed according to the existing codes.

Étanchéité et efficacité énergétique des habitations neuves au Canada en 1997 (maisons classiques et Maisons R-2000)

RÉSUMÉ

Ressources naturelles Canada, en collaboration avec la Société canadienne d'hypothèques et de logement et le Conseil national de recherches du Canada, a entrepris une étude nationale sur l'étanchéité et l'efficacité énergétique des nouvelles habitations, c'est-à-dire les maisons classiques et les Maisons R-2000, construites dans toutes les régions du sud du Canada. L'Association canadienne des constructeurs d'habitations a contribué d'une façon particulière à la sélection des habitations classiques construites par des entrepreneurs réguliers, un élément qui a rendu l'étude représentative du marché actuel. Les sociétés Hydro-Québec, Centra Gas, Manitoba Hydro et B. C. Hydro ont, pour leur part, fourni d'autres données utiles.

Le Canada compte parmi les chefs de file mondiaux de la production d'habitations destinées aux climats froids. La tendance générale qui se manifeste au pays visant à accroître l'étanchéité des maisons a permis d'augmenter l'efficacité énergétique, de diminuer les dommages causés par l'humidité et d'élever le niveau de confort. Il est possible de recueillir tous ces bénéfices sans pour autant provoquer des problèmes au chapitre de la qualité de l'air intérieur (QAI), problèmes découlant d'une ventilation inadéquate, d'une dépressurisation ou d'un rejet accidentel, et cela en apportant des améliorations à l'équipement de ventilation et en installant des appareils de combustion insensibles à la dépressurisation.

La base de données mise sur pied en vue de cette étude contient des renseignements détaillés concernant 163 maisons classiques neuves et 63 Maisons R-2000. Les maisons classiques neuves, qui ont été construites à partir de 1990 jusqu'à 1996, présentent un volume moyen de 652 m³, tandis que les Maisons R-2000, qui ont été construites à partir de 1983 jusqu'à

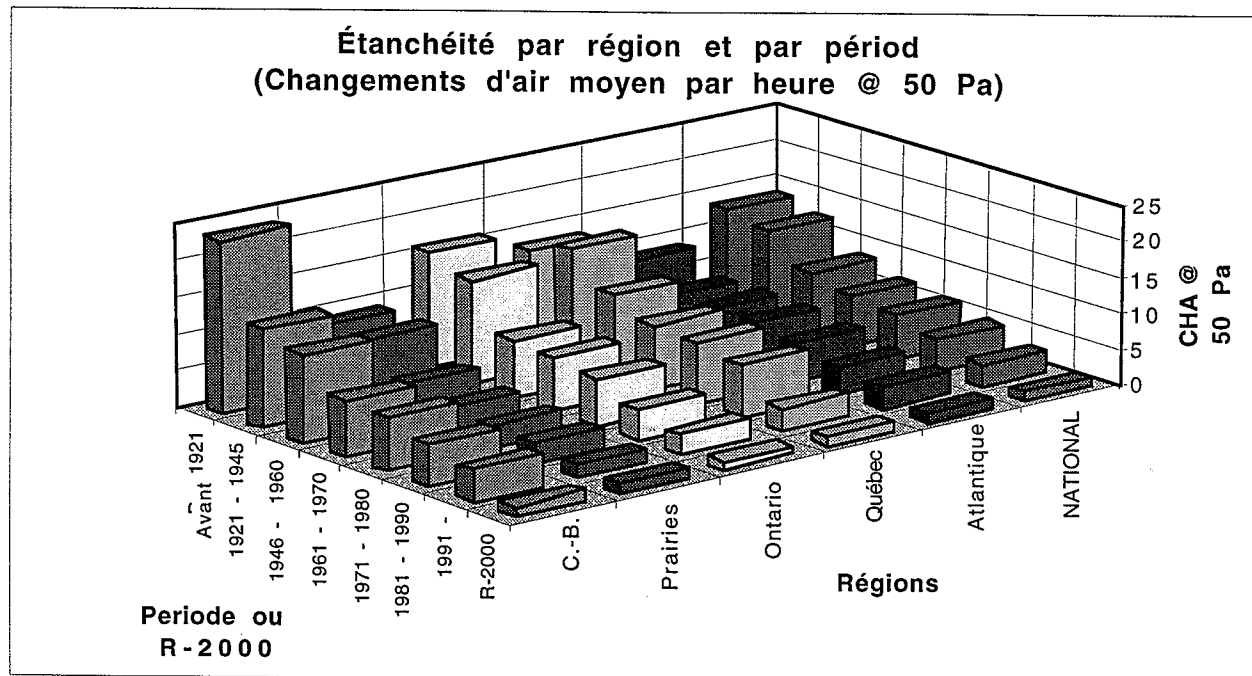


Figure R1. Étanchéité moyenne (changements d'air par heure @ 50 pascals) par région et par période, en plus de celle des Maisons R-2000 à titre de comparaison.

Rapport sur les maisons classiques neuves

1995, disposent d'un volume moyen de 792 m³, soit 22 % plus grand. Les données relatives à l'étanchéité qui se trouvent dans la base sont comparées aux tendances constatées dans le cas d'une étude portant sur 2 037 maisons érigées entre 1793 et 1996.

Tel que montré à la figure R1, on a analysé l'étanchéité de diverses façons et découvert une constante générale à accroître l'efficacité des maisons qui se manifeste avec des différences régionales importantes, bien que décroissantes. Malgré le fait que les Maisons R-2000 continuent à présenter une étanchéité et une efficacité énergétique plus grandes que les maisons classiques neuves, l'écart tend à diminuer. Ainsi, l'étanchéité des maisons classiques construites entre 1990 et 1996 est 35 % plus élevée que celle des maisons construites entre 1985 et 1989.

Régions	Nombre de maisons	Taux de changements d'air naturels (cha)			Maisons avec cha naturels inférieurs à:			
		Min.	Moyens	Max	Toutes les maisons <0,35	<0,20	Sans vent. méc. <0,35	<0,20
C.-B.	12	0,015	0,153	0,390	92%	75%	83%	67%
Prairies	69	0,017	0,156	0,426	97%	68%	22%	13%
Ontario	20	0,063	0,221	0,452	85%	55%	45%	25%
Québec	30	0,059	0,226	0,605	80%	50%	67%	40%
Atlantique	24	0,060	0,212	0,496	83%	63%	0%	0%
National	155	0,015	0,186	0,605	90%	63%	35%	22%

Tableau R1. Taux de changements d'air naturels, et possibilités de problèmes de QAI, des maisons classiques neuves.

Une plus grande étanchéité entraîne la nécessité de se doter d'une ventilation mécanique afin d'éviter les problèmes possibles reliés à la QAI. Cette étude a permis de constater que les maisons classiques neuves étaient suffisamment étanches pour nécessiter la présence d'une telle ventilation afin d'atténuer les problèmes de QAI, mais la plupart n'étaient pas dotées d'un système central de ventilation mécanique. Ces maisons devaient compter uniquement sur les ventilateurs de cuisine et de salle de bains, des mécanismes qui fonctionnaient rarement sans interruptions. À ce propos, veuillez vous référer au tableau R1. Les Maisons R-2000 font toutes preuve de grande étanchéité, disposant, cependant, de ventilateurs de récupération de la chaleur (VRC) qui sont conçus pour fournir suffisamment d'air frais lorsqu'ils fonctionnent sans interruptions.

Les maisons étanches sont également sujettes à la dépressurisation qui peut entraîner des rejets accidentels de produits de combustion provenant de l'équipement de brûlage des combustibles. Ce phénomène se produit lorsque les ventilateurs d'évacuation du bâtiment provoquent une baisse de la pression de l'air intérieur par rapport à l'air extérieur. C'est alors que les gaz de combustion provenant de la chaudière et du chauffe-eau peuvent être rejetés dans le bâtiment au lieu de monter par le carneau, ce qui peut causer de sérieux problèmes de QAI. Dans le cas des maisons dotées d'appareils susceptibles de provoquer des rejets, la dépressurisation maximale permise est de 5 pascals (Pa). Tel que montré à la figure R2, jusqu'à 40 % des maisons classiques neuves susceptibles de rejets sont sujettes à une dépressurisation plus grande de 5 Pa.

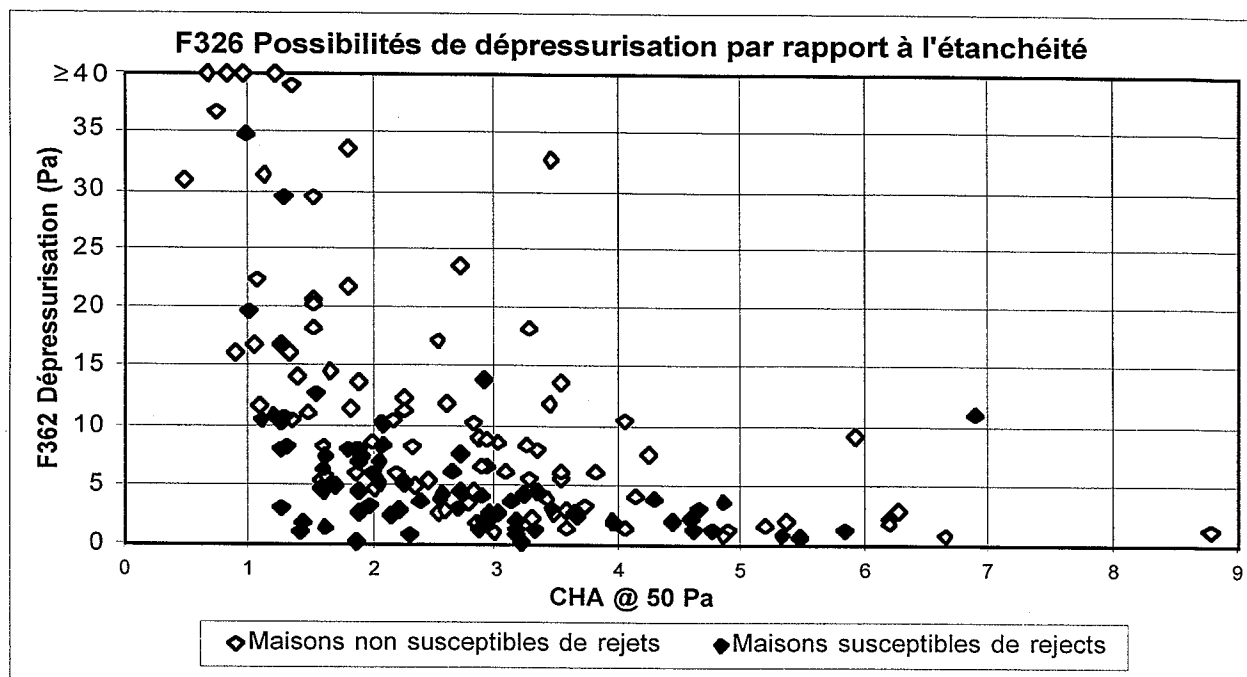


Figure R2. Possibilités de dépressurisation par rapport à l'étanchéité.

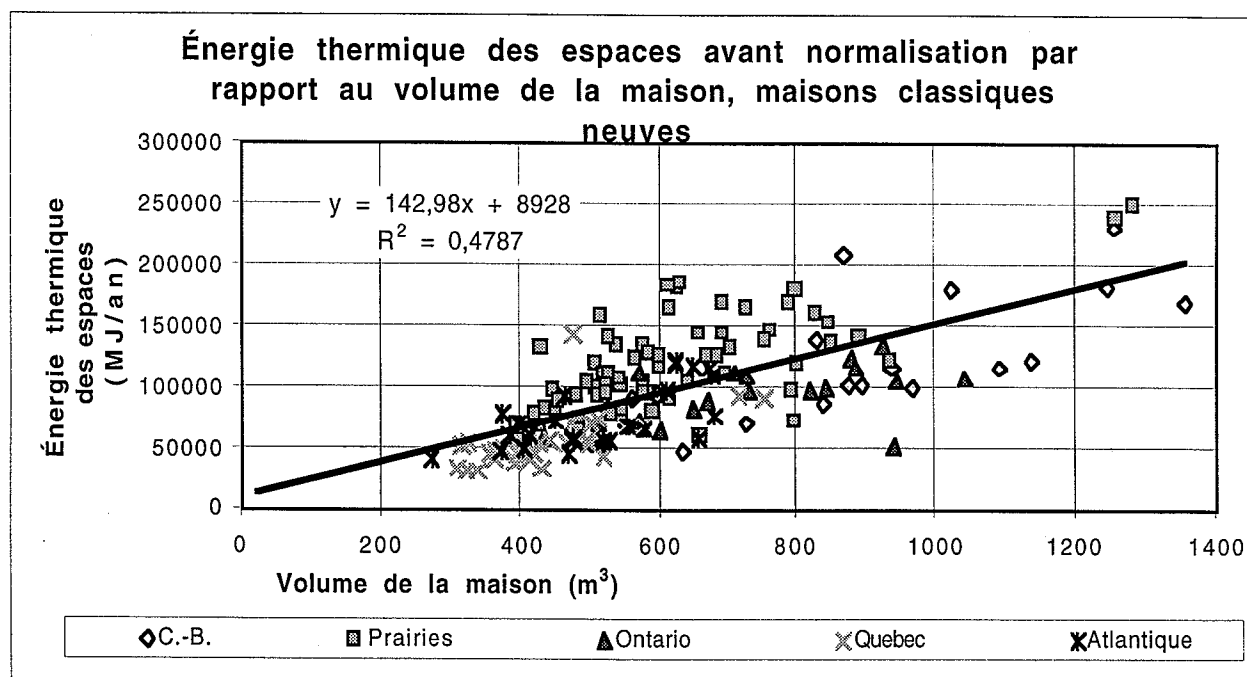


Figure R3. Énergie thermique des espaces avant normalisation par rapport au volume de la maison, maisons classiques neuves.

Rapport sur les maisons classiques neuves

Les Maisons R-2000 ne présentent aucun problème éventuel de dépressurisation en raison de leur ventilation équilibrée continue, en plus de la possibilité de recourir, le cas échéant, à de l'air d'appoint pour parer à tout problème de rejet provenant d'un appareil quelconque.

L'efficacité énergétique des maisons classiques neuves et des Maisons R-2000 fait l'objet d'un examen en s'appuyant sur l'énergie thermique des espaces et sur le tout récent Système de cotation ÉnerGuide pour les maisons. À ce chapitre, on a constaté des écarts significatifs entre les maisons classiques neuves et les Maisons R-2000, ainsi que des variations substantielles entre les diverses régions. En se basant sur l'ensemble des données obtenues, on s'aperçoit que les maisons classiques neuves consomment une moyenne de 93 gigajoules par année (GJ/an) pour le chauffage des espaces, un résultat qui varie de 56 au Québec à 119 dans les Prairies. En comparaison, les Maisons R-2000 consomment 70 GJ/an, un bilan, de 25 % moindre que dans le cas des maisons classiques neuves, qui varie de 41 au Québec à 101 dans les Prairies. Comme le montre la figure R3, les grandes maisons amènent une consommation énergétique plus importante que les petites, alors que la relation se rapportant à cet état de fait constitue, grosso modo, une courbe linéaire. Après normalisation en fonction de la taille, du climat et de l'efficacité du combustible utilisé, l'avantage que procurent les Maisons R-2000 monte de 33 %.

Le Système de cotation ÉnerGuide pour les maisons constitue une méthode de cotation de l'efficacité énergétique se rapportant à une maison donnée, le tout normalisé en fonction de la taille, du climat et de l'efficacité du combustible utilisé. Parce qu'il permet de normaliser la consommation énergétique par volume, ce système accorde aux grandes maisons, qui utilisent d'importantes quantités totales d'énergie, une cotation équivalente aux petites maisons qui utilisent des quantités totales d'énergie moindres. Compte tenu de la tendance actuelle vers la possession de grandes maisons avec peu d'occupants, même des améliorations substantielles aux cotations

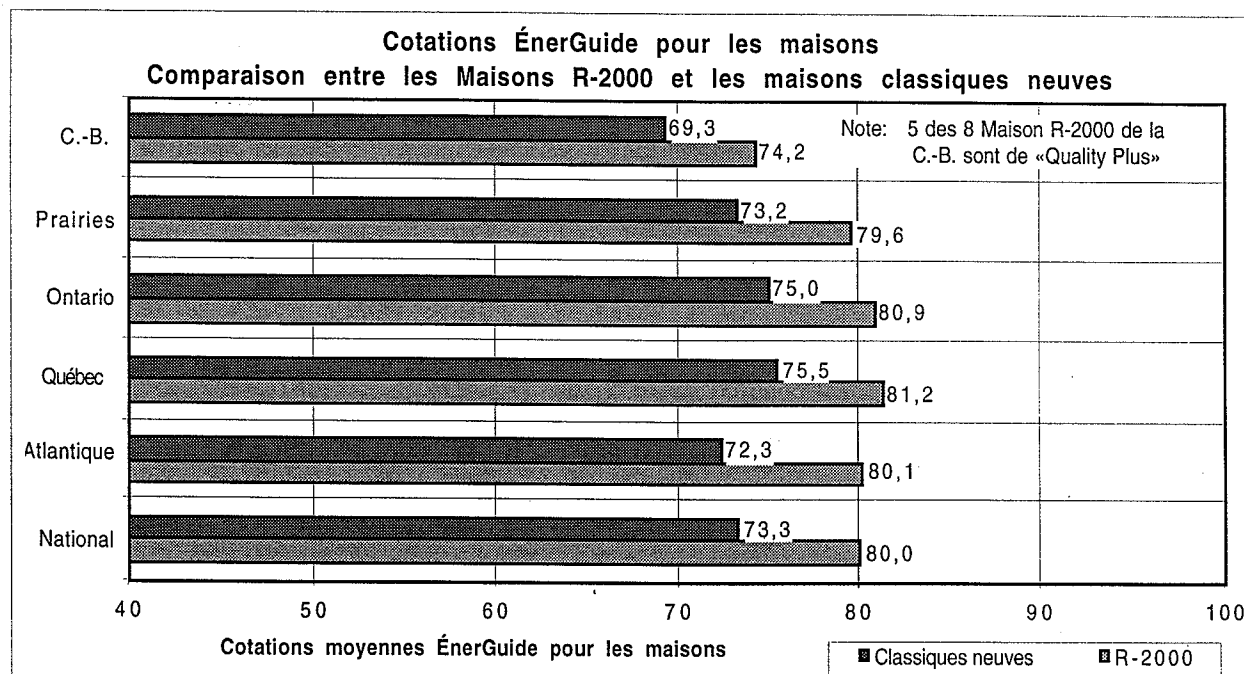


Figure R4. Cotations moyennes ÉnerGuide pour les maisons classiques neuves et les Maisons R-2000.

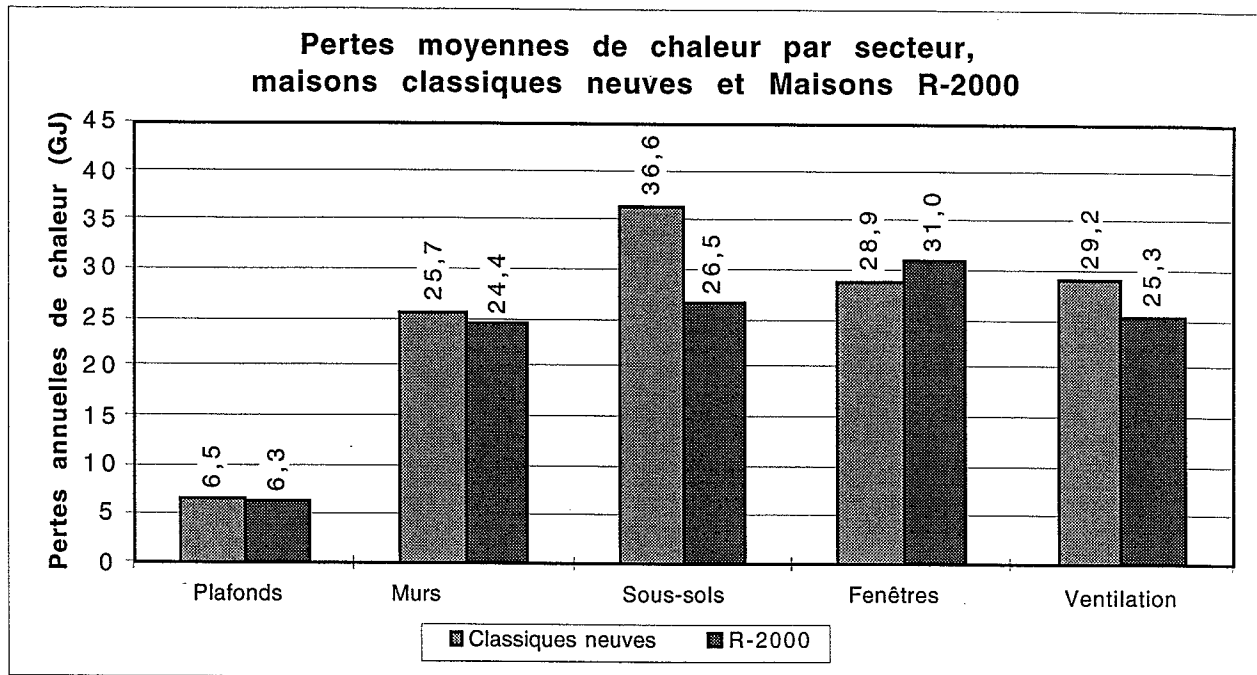


Figure R5. Pertes moyennes de chaleur par secteur, maisons classiques neuves et Maisons R-2000.

d'ÉnerGuide pourraient ne pas signifier une consommation énergétique atténuée pour l'habitation. En ayant recours au Système de cotation EnerGuide pour les maisons, les maisons classiques neuves obtiennent des résultats moyens de 73, alors que les Maisons R-2000 affichent une moyenne de 79. La figure R4 donne un tableau des variations par région.

La figure R5 indique les secteurs de pertes de chaleur dans les maisons classiques neuves et dans les Maisons R-2000. Les diverses colonnes que contient la figure montrent la quantité moyenne de chaleur perdue par les différents secteurs de l'enveloppe de la maison et en conséquence de l'utilisation de ventilation naturelle et mécanique. Il est intéressant de noter que les Maisons R-2000 perdent une quantité supérieure de chaleur par les fenêtres que les maisons classiques en raison de leurs dimensions plus vastes et des zones vitrées plus nombreuses. La plus grande différence s'est manifestée au niveau du sous-sol, alors que les maisons classiques neuves y ont perdu 38 % plus de chaleur que les Maisons R-2000 en dépit de leur taille inférieure. La comparaison faite entre la maison classique neuve à rendement énergétique maximum et celle du même genre à rendement énergétique minimum démontre clairement que la plus grande différence entre elles se situe au niveau des pertes de chaleur par le sous-sol : les 10 % de maisons les moins efficaces parmi cette catégorie ont laissé échapper plus de 40 % de leur chaleur par le sous-sol, tandis que les plus efficaces en laissaient passer environ 27 % par le même endroit. Ces résultats donnent à penser qu'il faut s'occuper en priorité de l'isolation des sous-sols.

Les maisons, au Canada, continuent à accroître leur étanchéité et leur efficacité énergétique. Les Maisons R-2000 sont toujours plus étanches et favorisent davantage l'efficacité énergétique que les maisons classiques neuves, mais l'écart se rétrécit sans cesse. L'étanchéité accrue des maisons suscite la possibilité de problèmes liés à la QAI, toutefois, on peut remédier à cette situation à l'aide de systèmes de ventilation et d'équipements de combustion installés selon les codes en vigueur.

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