LE PLAN VERT DU CANADA
CANADA'S GREEN PLAN

ADVANCED HOUSES PROGRAM
PROGRAMME DE MAISONS PERFORMANTES

DESIGN AND PERFORMANCE OF THE BRITISH COLUMBIA ADVANCED HOUSE

PREPARED FOR:

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Energy Technology Branch, Energy Sector
Department of Natural Resources
580 Booth Street
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Under Natural Resources Canada's Advanced Houses Program, 10 demonstration houses across the country were designed, built and monitored. The Program challenged the building industry to develop and test innovative methods of reducing energy consumption, providing a better indoor climate, and reducing the environmental impact of housing. The result was the erection of ten of the most environmentally responsible houses in the world, and the accumulation of valuable knowledge and experience, now documented in the Advanced Houses Program reports.

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Ken Cooper, SAR engineering ltd. and Richard Kadulski, architect, *Design and Performance of the British Columbia Advanced House.* CANMET File № EA-89810-A1. The CANMET Energy Technology Centre (CETC), Energy Technology Branch, Energy Sector, Department of Natural Resources Canada, Ottawa, Ontario, 1996. (83 pages).

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DATA FILE

Month	(separately bound)
1	September, 1994
2	October, 1994
3	November, 1994
4	December, 1994
5	January, 1995
6	February, 1995
7	March, 1995
8	April, 1995
9	May, 1995
10	June, 1995
11	July, 1995
12	August, 1995

EXECUTIVE SUMMARY

Natural Resources Canada (NRCan) sponsored the Advanced House Program to field test innovative technologies, products and building systems, to encourage manufacturers and suppliers to develop 'green' products, and to leverage support for research and development in the building sector.

The B.C. Advanced House demonstrates several important features:

- the viability of building energy efficient housing in an urban environment,
- the use of low emission materials to create a healthy indoor air environment,
- the use of low-flow faucets, and low water use appliances to make it possible to reduce overall and hot water usage,
- energy efficient envelope,
- energy efficient heating system.

The B.C. Advanced House was monitored, in an unoccupied condition, from 20 October, 1993 through 31 August, 1995. However, some sensors were not brought on line until July, 1994. Most of the data analysis presented in this report covers the period from September, 1994 to August, 1995.

Continuous hourly data, as well as monthly meter readings were obtained over the whole period. The hourly monitoring covered indoor and outdoor environment, as well as equipment operation and energy use.

Description:

The B.C. Advanced House is two storeys on an unheated crawlspace, with a heated area of 270 square metres. The stress-skinned roof has an RSI 7.75 insulating value, while the walls are RSI 5.25. The truss-floor over the crawlspace has an insulating value of 5.64, while the floor over the unheated garage is RSI 6.16. Windows are mostly triple glazed, double low-E coated and argon filled (RSI 0.74). Heated volume is 844 cubic metres and air tightness was tested at 1.4 air changes at 50 Pascals pressure differential (ELA of 470 square centimetres at 10 Pascals).

Space and water heating are provided by a condensing natural gas water heater plus fan-coil. A double core, cross-flow heat recovery ventilator provides continuous ventilation.

Environment:

From September, 1994 to August, 1995, the heating degree days at the house site amounted to 2,876 - only 5% more than at the Vancouver International Airport. Heating degree days at the airport were 9% less than long-term for the same period. Overall, conditions were slightly warmer than average.

Indoor temperatures and indoor air quality of the house were generally within acceptable comfort ranges. However, the house overheated during the summer period due to a combination of:

- solar heat gain (particularly in the master bedroom),
- heating system circulation when no heat called for (timed heating loop),
- lack of effective cooling system controls, and
- heat recovery by the HRV on hot days.

From September, 1994 to August, 1995, temperatures in the living room were typically in the 18C to 24C range. The ground floor master bedroom, on the southwest corner of the house, tended to overheat in the summer months, with 56% of the hours warmer than 24C.

Relative humidity averaged 54% in the summer and 41% in the winter in the unoccupied house.

Carbon dioxide concentration averaged about 420 ppm with a maximum hourly concentration of 828 ppm (house generally unoccupied).

One week indoor air quality tests showed formaldehyde concentrations, within six months of completion of construction, of less than 0.03 ppm - below the Health and Welfare recommended goal of 0.05 ppm. Formaldehyde whole house source strength at the same time was about 13 mL/h. One year later, with the house still unoccupied, formaldehyde source strength had dropped to less than 4 mL/h.

Although not an entirely reliable indicator, TVOC concentrations were 0.33 mg/m^3 about six months after completion of construction - falling to 0.05 mg/m^3 after one year. These are well below average for Canadian houses.

Overall, indoor air quality was an improvement over that found in conventional houses.

Mechanical Systems:

The integrated space and water heating system operated with an average heating season efficiency of only about 80%. This is less than expected, since the rated efficiency of the unit is 94%. Efficiencies from January to April were generally in excess of 90%, however.

The double core, cross-flow, heat recovery ventilator operated with a sensible core efficiency of 75% under winter conditions. This is reasonable for this unit, with a rated efficiency of 85% at 0 C, but operating an average of 11% out of balance.. The HRV fans used 79W, while delivering approximately 30 L/s of air flow.

Water and Energy Use:

Due to the house being unoccupied, hot water usage was very low and is not representative.

Electrical energy use amounted to 6,241 kWh per year, or 17.1 kWh per day, broken down to:

- 9.7 kWh per day for utilities (appliances, indoor lighting), including about 2.4 kWh per day for the monitoring system,
- 4.5 kWh per day for fan and pump energy, and
- 2.9 kWh per day for outdoor energy use.

The total for utilities, less 2.4 kWh per day for monitoring, plus energy for fans and pumps was 11.8 kWh per day - about equal to the 12.2 kWh per day budgetted for an occupied house.

Natural gas for space heating plus minimal water heating amounted to an energy equivalent of 6,025 kWh per year.

The total annual energy usage was 12,266 kWh, or 45.4 kWh per square metre of heated floor area per year.

Summary Compliance Table:

	Units	Budget	Predicted	Actual	Remarks
Space heating	kWh/yr	4,211	3,964	~5,745	split from space + DHW
Hot water	kWh/yr	5,520	3,250	~280	N/A (unoccupied)
Utilities: total	kWh/yr	4,436	6,482	6,241	including fans & pumps
fans & pumps	kWh/yr	0	2,278	1,643	
lights	kWh/yr	412	412	643	
outside	kWh/yr	183	183	1,072	security lighting
TOTAL	kWh/yr	14,167	13,696	12,266	

Ressources naturelles Canada (RNCan) a parrainé le Programme de la maison performante afin de mettre à l'essai des technologies innovatrices ainsi que des produits et des systèmes de construction en vue d'inciter les fabricants et les fournisseurs à élaborer des éco-produits et afin de stimuler les efforts de recherche et de développement dans le secteur de la construction.

La maison performante de C.-B. permet de mettre en valeur certaines caractéristiques importantes :

- viabilité des logements de type compact en milieu urbain;
- utilisation de matériaux à faible émissivité en vue de créer un environnement intérieur sain;
- installation de robinets à débit réduit et d'appareils ménagers à faible utilisation d'eau afin de diminuer la consommation totale d'eau (eau chaude comprise);
- enveloppe à haut rendement énergétique;
- installation de chauffage à haut rendement énergétique.

La maison performante de C.-B. a fait l'objet de contrôles systématiques du 20 octobre 1993 au 31 août 1995, pendant qu'elle était inoccupée. Toutefois, certains capteurs n'ont pas été mis en service avant le mois de juillet 1994. En conséquence, la plupart des données que nous présentons ont trait à la période allant de septembre 1994 à août 1995.

Pendant toute cette période, on a enregistré continuellement des données sur une base horaire et on a relevé les indications des compteurs une fois par mois. La surveillance horaire avait trait aux environnements intérieur et extérieur, au fonctionnement des équipements et à la consommation d'énergie.

Description

La maison performante de C.-B. est un bâtiment à deux étages construit au-dessus d'un vide sanitaire non chauffé. Sa superficie chauffée est de 270 mètres carrés. Le facteur de résistance thermique (RSI) du toit à structure panneautée est de 7,75, et celui des murs de 5,25. Le facteur RSI du plancher à structure en treillis recouvrant le vide sanitaire est de 5,64, tandis que celui du plancher recouvrant le garage non chauffé est de 6,16. Les fenêtres sont du genre à triple vitrage, à double revêtement faiblement émissif et à remplissage à l'argon (RSI 0,74). Le volume chauffé est de 844 mètres cubes. Les mesures d'infiltration d'air ont donné une valeur de 1,4 renouvellement d'air à une différence de pression de 50 pascals (SFE de 470 centimètres carrés à 10 pascals).

Le chauffage de l'espace et de l'eau est fourni par un chauffe-eau à condensation alimenté au gaz naturel combiné à un ventilo-convecteur. Un ventilateur-récupérateur de chaleur de type transversal à double élément assure une ventilation continue.

Environnement

De septembre 1994 à août 1995, les degrés-jours de chauffage de la maison se sont élevés à 2 876, soit 5 p. 100 seulement de plus qu'à l'aéroport international de Vancouver. Pendant la même période, les degrés-jours de chauffage à l'aéroport ont été inférieurs de 9 p. 100 à la moyenne à long terme. Dans l'ensemble, les températures ont été légèrement supérieures à la moyenne.

Les températures et la qualité de l'air à l'intérieur de la maison se sont généralement maintenues à des niveaux de confort acceptables. La maison a cependant été surchauffée pendant l'été en raison d'une combinaison de facteurs, à savoir :

- gain de chaleur solaire (surtout dans la chambre principale),
- apport non nécessaire de chaleur par l'installation de chauffage (boucle de chauffage commandée par minuterie),
- absence de commandes efficaces pour le système de refroidissement
- récupération de chaleur par le ventilateur-récupérateur de chaleur lors des jours très chauds.

De septembre 1994 à août 1995, les températures à l'intérieur du salon se sont généralement maintenues entre 18 °C et 24 °C. La chambre principale du rez-de-chaussée, située à l'angle sud-ouest de la maison, avait tendance à être surchauffée en été, la température moyenne y étant supérieure à 24 °C durant 56 p. 100 du temps.

L'humidité relative dans la maison inoccupée était en moyenne de 54 p. 100 en été et de 41 p. 100 en hiver.

La concentration moyenne de dioxyde de carbone était de 420 ppm, mais on a noté une concentration horaire maximale de 828 ppm (la maison étant généralement inoccupée).

Pendant une semaine, au cours de la période de six mois ayant suivi la fin des travaux de construction, les mesures de la qualité de l'air intérieur ont indiqué des concentrations de formaldéhyde inférieures à 0,03 ppm, c'est-à-dire plus basses que la concentration maximale recommandée (0,05 ppm) par Santé et Bien-être. Pendant la même période, le débit de la source de formaldéhyde dans toute la maison était d'environ 13 mL/h et, un an plus tard, la maison étant toujours inoccupée, elle était tombée à moins de 4 mL/h.

Bien qu'il ne s'agisse pas d'un facteur très fiable, les concentrations totales de COV étaient de 0,33 mg/m^3 six mois environ après le parachèvement de la construction, et de 0,05 mg/m^3 au bout d'un an. Ce sont là des chiffres bien inférieurs aux moyennes enregistrées dans les habitations canadiennes.

Dans l'ensemble, la qualité de l'air intérieur représentait une amélioration par rapport à celle des maisons traditionnelles.

Installations mécaniques

Le système intégré de chauffage des locaux et de l'eau n'a présenté une efficacité moyenne de fonctionnement en saison froide que d'environ 80 p. 100. C'est un taux inférieur aux prévisions puisque l'efficacité nominale de l'installation est de 94 p. 100. Néanmoins, de janvier à avril, les rendements ont généralement dépassé 90 p. 100.

Le ventilateur-récupérateur de chaleur de type transversal à double élément a présenté un rendement intéressant au niveau des éléments puisqu'il a atteint 75 p. 100 en hiver. Il s'agit d'un résultat convenable pour cet appareil étant donné que son rendement nominal est de 85 p. 100 à 0 °C; il fonctionnait cependant en déséquilibre pendant environ 11 p. 100 du temps. Les ventilateurs de l'appareil consommaient 79 W et faisaient circuler environ 30 litres d'air à la seconde.

Utilisation de l'eau et de l'énergie

La maison étant inoccupée, la consommation d'eau chaude était très faible, donc non représentative.

La consommation annuelle d'énergie électrique s'est élevée à 6 241 kWh, soit 17,1 kWh par jour, que l'on peut répartir ainsi :

- 9,7 kWh par jour pour les besoins courants (appareils ménagers, éclairage intérieur), y compris 2,4 kWh par jour pour le système de surveillance;
- 4,5 kWh par jour pour les ventilateurs et les pompes;
- 2,9 kWh par jour pour les besoins extérieurs.

Le total pour les besoins courants, moins les 2,4 kWh nécessaires aux instruments de surveillance, plus l'énergie requise pour les ventilateurs et les pompes, était de 11,8 kWh par jour, soit une consommation à peu près égale à celle de 12,2 kWh par jour budgétée pour une maison occupée.

La consommation de gaz naturel pour le chauffage des locaux et d'une quantité d'eau minime s'est avérée équivalente à une consommation d'électricité de 6 025 kWh par an.

La consommation totale annuelle d'énergie s'est élevée à 12 266 kWh, soit 45,4 kWh par mètre carré de superficie chauffée par an.

Tableau de conformité sommaire

	Unités	Budgét-ées	Prévues	Réelles	Remarques
Chauffage des locaux	kWh/an	4 211	3 964	-5 745	pris du total pour le chauffage de l'espace et de l'eau domestique
Eau chaude	kWh/an	5 520	3 250	-280	S/O (inoccupée)
Services publics : total	kWh/an	4 436	6 482	6 241	Incluant ventil & pompes
ventil. et pompes	kWh/an	0	2 278	1 643	
éclairage	kWh/an	412	412	643	
Extérieur	kWh/an	183	183	1 072	éclairage de sécurité
TOTAL	kWh/an	14 167	13 696	12 266	