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CANADA'S GREEN PLAN

ADVANCED HOUSES PROGRAM
PROGRAMME DE MAISONS PERFORMANTES

DESIGN AND PERFORMANCE OF THE BRITISH COLUMBIA ADVANCED HOUSE

PREPARED FOR:

Buildings Group/CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources
580 Booth Street
Ottawa, Ontario, K1A 0E4
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PREPARED BY:

Ken Cooper
SAR engineering ltd.
8884 - 15th Avenue
Burnaby, B.C.
Phone: (604) 525-2239

Richard Kadulski, architect
208 - 1280 Seymour Street
Vancouver, B.C.,
V6B 3N9
Phone & Fax: (604) 689-1841

SCIENTIFIC AUTHORITY

Buildings Group/CANMET Energy Technology Centre
Energy Technology Branch, Energy Sector
Department of Natural Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4

ADVANCED HOUSES PUBLICATIONS LIST

Advanced Houses Program
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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...1/2

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	Application of R-2000 and Advanced House Energy Standards in Affordable Homes in Canada *Assesses optimization of energy-efficient technologies for affordable housing and assesses cost effectiveness and impacts of energy-efficient mortgages, by R. Kevin Lee, 34 pages, 1995.*	$10
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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

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	Budgétées	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	

1 ADVANCED HOUSE PROGRAM

1.1 Introduction

This report is organized in two main parts:

- Sections 1 to 5 - Leading up to completion of the B.C. Advanced house -
  - Advanced house program background
  - Design
  - Construction
  - Predicted performance
  - Monitoring program
- Sections 6 to 9 - Results from construction and operation of the B.C. Advanced house -
  - Monitored results
  - Environmental aspects
  - Technology assessment
  - Conclusions

The report was written to meet the needs of housing policy makers, building science researchers and of builders interested in low energy, environmenally concious housing.

1.2 Background

1.2.1 NRCan CANMET Advanced Houses Competition

The Advanced Houses Program developed a pilot program to field test innovative technologies, products and building systems and to assess their overall performance and suitability for adoption by mainstream builders. The aim of the program is to benefit both consumers and the Canadian housing industry to remain on the cutting edge of technological innovation and product development. The Advanced Houses are intended to be truly world class in their features and performance.

Natural Resources Canada (NRCan) sponsored the Advanced House Program[1] to demonstrate to the Canadian public and housing industry that it is possible to design houses for the Canadian climate which are in keeping with the principles of sustainable development, which offer healthy indoor environments, and which remain affordable.

The key to commercialization and market acceptance of new building products or systems is a demonstrated track record of reliable and predictable performance. Over the last decade Energy Mines and Resources (now NRCan) has monitored and evaluated the performance of a number of innovative technologies for the housing industry. The R-2000 Program, Canada's leading edge energy efficient housing program, is one example where these technologies have been evaluated under field conditions.

On-going monitoring of R-2000 houses has been the cornerstone in accelerating the adoption of new technologies and development of new

[1] Funding for the B.C. Advanced House was also provided by many corporate.sponsors - see section 2.2

standards for the R-2000 Program and for the housing sector as a whole. The results of this monitoring work has in many cases stimulated adoption by mainstream builders of new technologies or building practices, or stimulated the development of new or improved products and standards. In some cases the findings of the monitoring work has provided the basis for proposed revisions to the R-2000 Program. Some of these new products and program revisions are currently being tested in one of Canada's Green Plan initiatives, the Advanced Houses program.

In the short time since the first Advanced House was constructed in Canada, environmental issues have moved to the forefront of society's awareness and concern. Housing professionals, researchers, educators and governments at all levels have been striving to define and demonstrate "green" or "sustainable" housing and show what its implications are, not only for the environment, but for the entire Canadian building industry.

In 1992, eight Advanced Houses were selected for detailed monitoring. The houses were located in Saskatoon, Saskatchewan; Winnipeg, Manitoba; Waterloo, Ontario; Ottawa, Ontario; Montreal, Quebec (two houses), Halifax, Nova Scotia, and in Surrey, B.C..

1.2.2 Advanced House Design Criteria

Energy Criteria

The Advanced houses had to meet specified technical requirements[2], including the following energy targets:

- Total energy target (kWh):

$$Q_T = Q_s + Q_c + Q_w + Q_a + Q_l + Q_o$$

- Annual space heating target (kWh):

$$Q_s = SVF \times OF \times W \times (2.5 + 27.5 \times DD/6000) \times V/2.5$$

SVF = surface/volume factor
= 2.14 - 0.00308 x V + 0.000001668 x V^2
OF = occupant factor
= 1.0 if Volume/no. bedrooms 171 or less
= 0.9 if Volume/no. bedrooms is 172 to 250
= 0.8 if Volume/no. bedrooms is more than 250
W = 1.0 for electric heat; 1.2 for natural gas or oil heat
DD = annual space heating degree days to a base of 18C
V = interior heated volume, including basement (m^3)

- Annual space cooling target (kWh):

$$Q_c = 0.007 \times CDD \times V/2.5$$

CDD = annual cooling degree days to a base of 18C

- Domestic water heating (kWh)

$$Q_w = 2300 \times GF \times N/3$$

GF = 1.0 for electric heat; 1.8 for natural gas or oil

[2] *"Advanced Houses Program Technical Requirements"*, by R. Dumont, SRC for CANMET NRCan. June, 1992, see Appendix D, [1] (numbers in square brackets refer to References, section 10)

N = number of bedrooms
The hot water used is assumed to be 78.7 x N, (L/day) at 50C
Electric water heating had to have a minimum COP of 2.0

- Electrical appliance target (kWh):
  $Q_a = 3838$
- Lighting target (kWh):
  $Q_l = 250 \times V/512$
- Outdoor electrical usage (kWh):
  $Q_o = 183$

Electrical power consumption for fans, in houses with forced warm-air heating, was required use less than 0.75 W/L/s of combined circulation and ventilation air flow.

The Advanced Houses were targeted to use between 30 and 70 kWh/m^2 of total energy consumption per year, whereas houses built to the 1975 National Building Code of Canada are using approximately 200 to 300 kWh/m^2 per year. R-2000 houses use approximately 160 kWh/m^2 (average of six houses in Alberta and Ontario)[3].

Indoor Air Quality (IAQ) Criteria:

The house was designed to be ventilated at levels dictated by the F326 standard. In addition, the house incorporated a variety of emission control measures as dictated by the Advance House requirements:

- strive to incorporate building products that have low off-gassing of air pollutants
- do not use products containing urea-formaldehyde-based resin glues unless the room in which the product is used meets the target guideline of 0.05 ppm formaldehyde while using the prescribed ventilation rate.

Environmental Criteria:

The goal was to reduce the impact of the house on the environment, by:

- reducing water usage,
  - low consumption toilets (less than 7 litres per flush),
  - low consumption shower heads (less than 10 L per minute at 551 kPa),
  - aerators on all sink faucets,
  - low consumption clothes-washing machine, and
  - water-efficient landscaping
- recycling: provide space in or near the kitchen for -
  - compost (10L minimum)
  - papers, metal and glass (sufficient space for recycling blue box)
- ecomanagement
  - where possible, use recycled materials for construction,
  - minimize constuction waste, and
  - where possible, use EcoLogo products

[3] *"R-2000 Monitoring Program Data Processing Results"* by K. Cooper, for NRCan, March 31, 1995. [3]

2 B.C. ADVANCED HOUSE DESIGN

2.1 Overview

Design Philosophy

The design of the house is sensitive to the geographical, social and technical realities of the Vancouver residential market. The intent was to demonstrate state-of-the-art building technologies for energy efficient construction and environmentally sensitive design.

Design Process

Once the property selection was made and acquired, the original design was modified to suit site requirements, including zoning and municipal design controls.

Technical and design consultations with interested stakeholder groups were undertaken prior to finalizing the design. Issues covered included:

- mechanical systems options and designs,
- building envelope and structural systems,
- building materials and products,
- home automation systems, and
- site considerations, including landscaping.

Changes to the Design

The original design incorporated a full basement, which would have provided ample space for mechanical systems, plus added space for monitoring equipment, displays and meeting spaces. However, sewer services at the site are too shallow (due to a shallow frost depth), to allow for a basement, so the final design incorporated an unheated crawlspace.

Crawlspaces are the most common foundation approach used in the Vancouver area. However, most crawlspaces are insulated and heated, generally because it is easier for the builder to insulate the walls than the floor over the crawlspace. It also provides a simple conditioned space for heating ducts and plumbing. However, a heated crawlspace increases the total heated volume, which, together with the usually uninsulated floor results in a significant energy penalty.

Since there was no basement, adjustments had to be made to the floor plan to provide adequate space for mechanical systems and general utility storage space - hence the seemingly ample utility room on the main floor. The double garage was used for meeting and display space - with the garage door replaced by a wall and French door (see Figure 2.3) during the open-house period.

2.2 Administration

2.2.1 Project Team

The project was handled under the umbrella of a not-for-profit assiciation that was incorporated, under the provisions of the Companies Act of British Columbia, specifically for this project. The five person Board of Directors included two nominated by the executive of the Canadian Home Builders Association of British Columbia. Board members were: Richard Kadulski, Warren Jones, David Hill, John Zuk, and Richard Stewart.

Principal team members to undertake the construction and marketing of the project included:

- Project Manager and architect: Richard Kadulski,
- Assistant to Project Manager: William A. Gies,
- Builder: Warren Jones (Cortez Energy Efficient Homes),
- Energy systems, technical design and monitoring: Ken Cooper (SAR engineering ltd.),
- Heating & Ventilation layout and system design: David Hill (Eneready Products Ltd.),
- Home Automation: Ludo Bertsch (Horizon Technologies Inc.),
- Structural design: Paul Fast (Fast & Epp Partners),
- Electrical: Bernard Crocker (B.C. Hydro and Power Authority),
- Interior design: Diane Quintin (Design Plus Consultants),
- Landscape design: Richarc Stevenson, BCSLA, and
- Marketing: Ken Farrish (Farrish Marketing).

2.2.2 Project Sponsors and their Objectives

Natural Resources Canada, or NRCan (CANMET Buildings Group):

- to encourage and showcase leading edge technology to reduce energy consumption in Canadian homes and to reduce the impact of housing on its environment.
- to accelerate the introduction of energy efficient and environmental technologies

B.C. Hydro and Power Authority:

- to promote their energy conservation initiatives (Power Smart).

B.C. Gas:

- to encourage the wise use of natural gas.

B.C. Telephone:

- to assess home automation and the potential for intelligent communications,
- to undertake remote metering, and
- to become the information centre for home automation initiatives.

B.C. Ministry of Energy, Mines and Petroleum Resources

CHBA - B.C.:

- to promote leading edge technology and showcase the professional home building industry.

B.C. Ministry of Environment, Lands and Parks

Residential Construction Institute:

- to promote educational opportunities for the residential building industry.

Envisafe Cabinets 2000: a new company, with a mission to manufacture environmentally responsible, low emissions, millwork.

All Weather Windows: the B.C. sales office was relatively new so they were enthusiastic to gain exposure for high performance windows they manufacture.

C-Max Technologies: developers of a new wood fibre-based technology to manufacture a wide range of composite wood products. One included fire-proof roof tiles, which were made as a prototype to look like roofing slates.

Royal-Lepage Real Estate, Langley B.C. branch provided staff for the open house period.

Eneready Products Ltd. for mechanical systems design and product.

Council of Forest Industries of B.C. who provided design and testing services for the prototype stressed-skin panels.

Numerous building product suppliers came on board as the project was developing and being built.

2.2.3 Project Problems

The first major problem was the difficulty in finding a suitable property on which to build the house. In the booming Vancouver real estate market at the time, there were few available lots to be had, and there was no incentive for developers to make a lot available, which might have generated extra traffic to their project.

The second major problem was obtaining adequate financial support for the project. As there was no major local participant with adequate resources that was fully committed and could act as the key local sponsor, a considerable effort was required to generate contributions from many sources. The project team were not adequately prepared for the fund-raising that was required for this type of project. In the end, a very high ratio mortgage was obtained, with the expectation that the funds would be recouped through the sale of the house at a premium price.

Many potential sponsors with a legitimate interest in the housing industry were either not open to support the project or did not understand the nature of the overall project. Many viewed it purely as a marketing exercise, in which case the project either did not mesh with their goals or their marketing strategy.

It was viewed as lacking adequate scientific research for the B.C. Science Council to provide support, while it was considered too much a scientific exercise for the Real Estate Foundation, who did not understand how advanced building technologies would enhance the real estate industry.

Because of the shortfall in cash contributions, and the necessity to allow for mortgage interest charges over the one year demonstration period, it was imperative to sell the house at a substantial premium. Unfortunately, due to a softening of the real estate market when the house came on the market, the house was not sold until a year after the open house period finished, and then only after the financial institutions involved took a loss.

Pressures of a fixed opening date, precipitated by the need to have the project substantially complete in time for the International Housing Conference in Vancouver meant that considerable work had to be done before all contractual and financial arrangements could be finalized. This created additional financial stress and put the project in jeopardy.

2.2.4 Accounting

Unscheduled expenses were incurred when the original stress-skin supplier pulled out of the project. At the time, the project was committed to construction with stressed-skin panels. The COFI structural lab had tested prototype panels and made design reommendations. There being no other local manufacturer of such panels in the area, the decision was made to fabricate the panels. Fortunately, a local fabricator of insulated custom curtain wall panels for commercial applications was moving their factory, and had a heated press suitable for manufacture of panels required for the design.

The landlord of the industrial park allowed the use of the premises for the manufacture of the panels, at a reduced rental rate, but it was still an unbudgeted expense. An additional cost was the purchase of the polyurethane resin, which had to come from California, as that was the only source that could provide an HCFC formulation at the time. The supplier implied that had the resin been available in Canada, the project would have received it at no charge. These changes cost the project an unbudgeted $16,000.

The pressure to have the house completed in time for the International Housing Conference in Vancouver in June, 1993 also contributed to extra costs, as we did not have the luxury of negotiating the best deals for products and services.

The Financial Statement is included in Appendix E. Value of in-kind contributions are not factored into the Financial Statement. Due to the shortfall in funds, and the lack of purchasers willing to pay a premium for the house, the Bank took the house and the the agreement of the mortgage insurer, the house was sold in August, 1995 for a price of $285,000. The price was established to effect a quick sale, and was 5% below the market value of average houses in the immediate area.

A number of creditors were obliged to write off a total of $62,000 in outstanding payables. A major portion of the outstanding balance was due to the project manager and construction manager for services rendered, whose fees were deferred to the end.

2.3 Description of B.C. Advanced House

2.3.1 House Location and Form

The house was located in the Coverdale area of Surrey, B.C., a typical suburban community, near the centre of the growth area of Metropolitan Vancouver. The location is close to major traffic corridors, adjacent to a newly developing town centre with adequate visitor parking near the site. The selection of a newly developing suburb addressed several concerns:

- It is an area where there is much building activity going on, so that trades, suppliers and building officials are already in the area - exposing the house to a group that might not travel large distances to see new technology.
- It is an area where prospective home buyers are looking for new homes.
- It demonstrates how environmentally-appropriate technology is compatible with existing site plans, zoning and design features of contemporary Canadian homes.

At 270 square metres on two floors, the house is slightly under the average size of new housing in the area. It incorporates vaulted ceilings to provide an aesthetically pleasing and liveable interior house volume. The peaked roof configuration reflects the forests and mountains of the region and takes advantage of panelized construction. It reintroduces the 'room in the attic' as living space.

The West Coast has long periods of heavy overcast, especially in the winter. To provide natural light inside to compensate for the gloomy conditions and to demonstrate the changes in glazing technology, the house design incorporates large glass areas. This shows that it is not necessary to have minimial glazed areas if one wants an energy efficient home.

Other design features include:

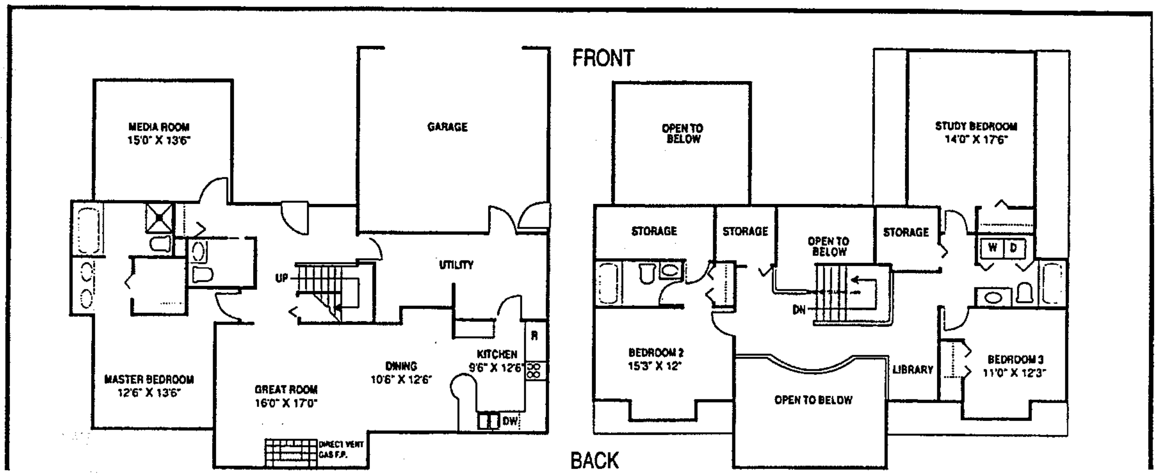
- an open plan that reflects casual west coast lifestyles,
- vaulted ceilings create visual interest and a sense of greater interior space, yet the exterior provides a smaller scale appearance,
- ample room and storage spaces, and
- a design that maximizes solar gains.

The design also accommodates changing family circumstances:

- media room could be a home office or a bedroom for a disabled person,
- home office could be an extra bedroom or children's play area

2.3.2 Description of House

Figure 2.1 B.C. Advanced House Floor Plans



Total heated floor area of 270 square metres plus 42.9 square metres of unheated garage.

The following description of the B.C. Advanced house includes a number of innovative or prototypical products and systems not used in standard construction:

- Roof construction -
  - C-Max roof tiles made from the waste by-products of the local pulp and fertilizer industries[4]
  - 2x4 strapping,
  - roofing felt,
  - stressed-skin, pre-fabricated panels (16 mm exterior plywood and 10mm interior plywood faces), filled with 188 mm polyurethane foam (RSI 7.75 total), and
  - 16 mm gyproc with low VOC paint
- Unheated crawlspace -
  - 16 mm plywood subfloor,
  - 235 mm truss joists blown cellulose insulation in the floor (RSI 5.6), and
  - 10 mm plywood panel facing crawlspace

    Floor of crawlspace -
  - 50 mm concrete skim coat,
  - 6 mil polyethylene vapour barrier, and

[4] C-Max roof tiles, a prototype product, with no manufacturing plant in operation or even contemplated at the time, had to be made by hand in small batches. This led to considerable delivery delays (the roof was not completely installed until several months after the house had been opened to the public), and some inconsistency in tile quality (some tiles appear to be weaker than others). The product is a cementitious composite material using cellulose fibre (in this case, fibres not usable by local pulp and paper mills) and a portland cement material that is a by-product of the fertilizer industry.

- 150 mm minimum crushed green glass and rock (40% glass)

- Most windows are triple-glazed, double low-E coated and argon filled with thermally broken wood frames and insulating spacers. Opening units with narrower spaces between glazings used krypton gas fill to maintain the high thermal resistance,

- A wide overhang and passive louvers over main south side windows in the living room provide shade to reduce summer overheating.

Figure 2.2 Southwest corner of house

Figure 2.3 North elevation

- Siding was kiln-dried factory prefinished cedar that comes with a 10 year warranty, extendable to 20 years. Kiln drying and factory finishing reduces site waste, as sorting of unusable material is done by the producer, and the off-cuts and "waste" can be used for other wood products that use wood fibre,

- Engineered wood products were used for structural framing: wall framing for interior partitions and in the main floor exterior walls were finger jointed studs. Floor framing was wood I-joists, roof ridge beams were Parallam, a parallel strand engineered wood beam.

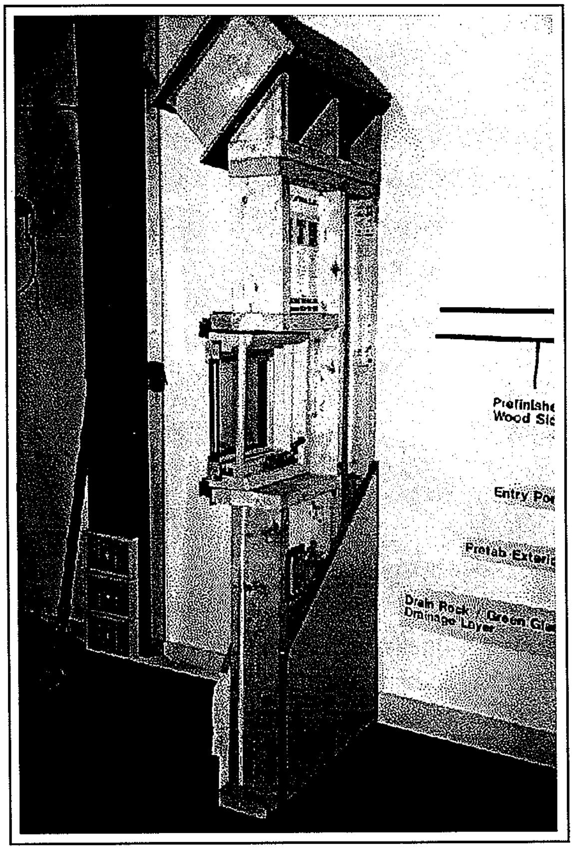
Two types of walls were used in the construction of the B.C. Advanced house:

- Sheathed walls (non-gable walls), Figure 2.4 -
  - vertical cedar siding
  - Taped polyolefin wind barrier,
  - 2x6 advanced framing stud wall at 600 mm on centres, filled with 140 mm high density expanded polystyrene insulation; incorporates a plastic lock strip that makes the structure inherently more air-tight than conventional framing,
  - interior 2x2 strapping filled with fiberglass insulation, and
  - 16 mm gyproc with low VOC paint

Table 2.1 Summary Characteristics

2 storey, on crawlspace		
Heated Floor Area	(m^2)	270
Volume	(m^3)	843.7
Envelope area	(m^2)	704.9
Insulation Levels		
Ceiling	(RSI)	7.75
Walls	(RSI)	5.25
Crawlspace floor	(RSI)	5.64
Floor over garage	(RSI)	6.16
Windows (average)	(RSI)	0.74
Air tightness at 50 Pa	(ac/h)	1.40
ELA	(cm^2)	470
NLA	(cm^2/m^2)	0.67
Dual core cross-flow HRV	(0C effic.)	85%
Window area	(m^2)	40.9
South	(m^2)	22.9
Fraction of floor area	(%)	8%
Shading		~40%
Integrated condensing boiler	(effic.)	94%
Occupants		0
Monitoring average power	(W)	100

Figure 2.4 Sheathed Wall Section
(gable walls similar to roof section shown)



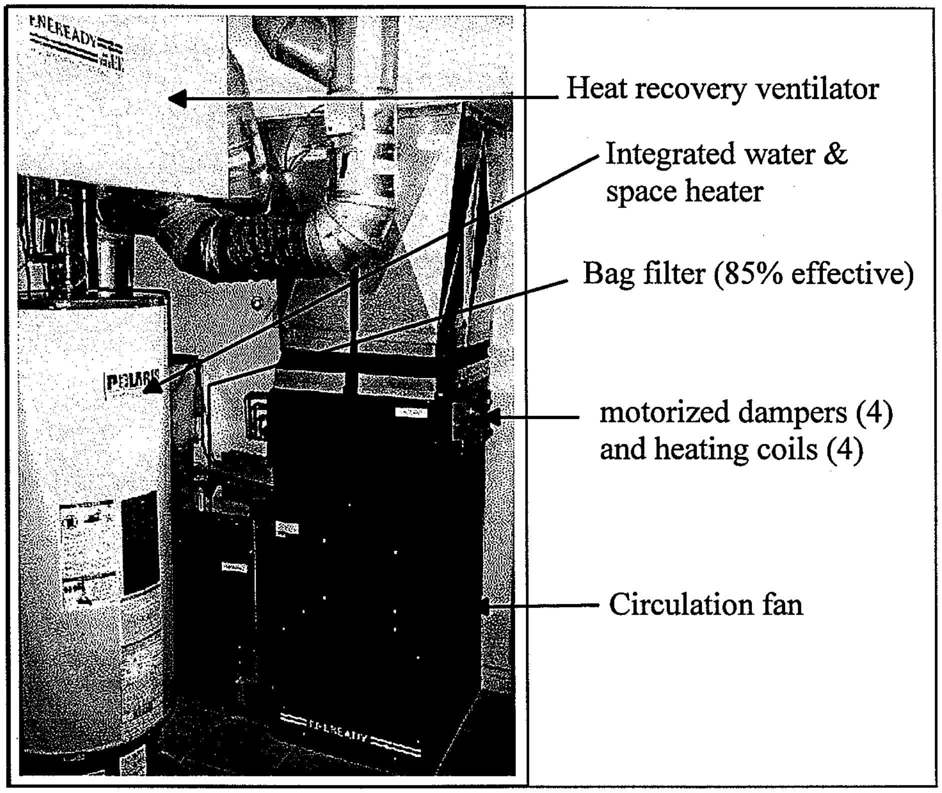
- Stressed-skin gable walls (similar to roof section shown at top of figure 2.4, except only 140mm thick) -
  - vertical cedar siding

- Taped polyolefin wind barrier,
- stressed skin panel - plywood faces and 140 mm polyurethane foam insulation,
- 16 mm gyproc with low VOC paint

The space conditioning and water heating system consists of:

- a condensing natural gas integrated space and domestic water heater,
- a 6.0 square metre pumped solar system with a 180L DHW pre-heat tank,
- a custom four zone fan-coil air distribution system with an electronically commutated high efficiency fan,
- a six zone radiant heating system for kitchen, bathrooms and utility room, drawing heat through an isolation heat exhanger,
- a circulation fan at 500L/s with motorized damper to draw 100% outside cooling air interlocked with a motorized skylight for pressure relief ,
- an 85% efficient bag filter in the return air/fresh air duct, and
- a CEBus control system using zone temperature to control zone heating.

Figure 2.5 Mechanical system



The ventilation system consists of:

- a dual core, cross-flow HRV (85% efficient at 0 C) with 90 L/s capacity,
- a CEBus controlled, four zone system, with occupancy sensors to provide better distribution of ventilation air - enabling a reduction in overall ventilation rates, and

- user activated, timer-controlled variable bathroom intakes allowing up to about 60% of HRV system exhaust flow to be drawn from one location.

Problems with the mechanical system included a fan coil air handler that was of unacceptable quality (ill-fitting components, insufficient rigidity), so a custom unit was manufactured. Also, the ECM motor unit delivered was not prepared according to specifications, so a replacement unit had to be acquired directly from the manufacturer.

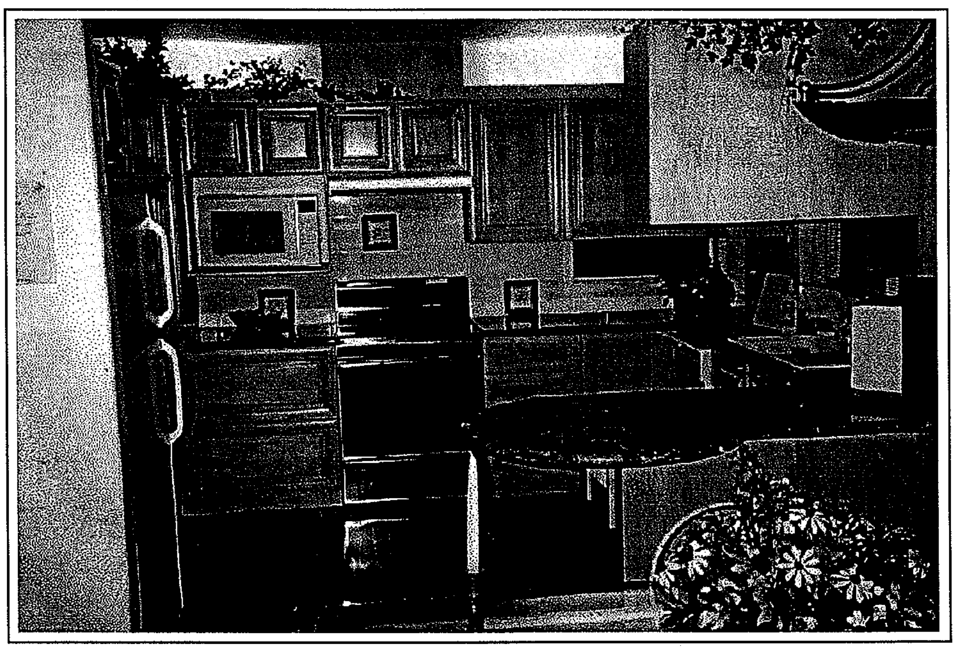
The energy efficient DC motors for the HRV were prototypes that had "bugs" in the control circuits. The units eventually had to be replaced with high efficiency, variable speed AC motors.

The prototypical CEBus home automation control system[5] incurred long delays in delivery. Most control modes have been implemented, however only a simplified, switch-controlled "free-cooling" mode was included.

Air quality features included finish materials that were selected to minimize VOC emissions (Figure 2.6):

- counter- top is natural granite,
- cabinets are manufactured from non-formaldehyde based composite boards, and finished with water-based finishes,

Figure 2.6 Kitchen



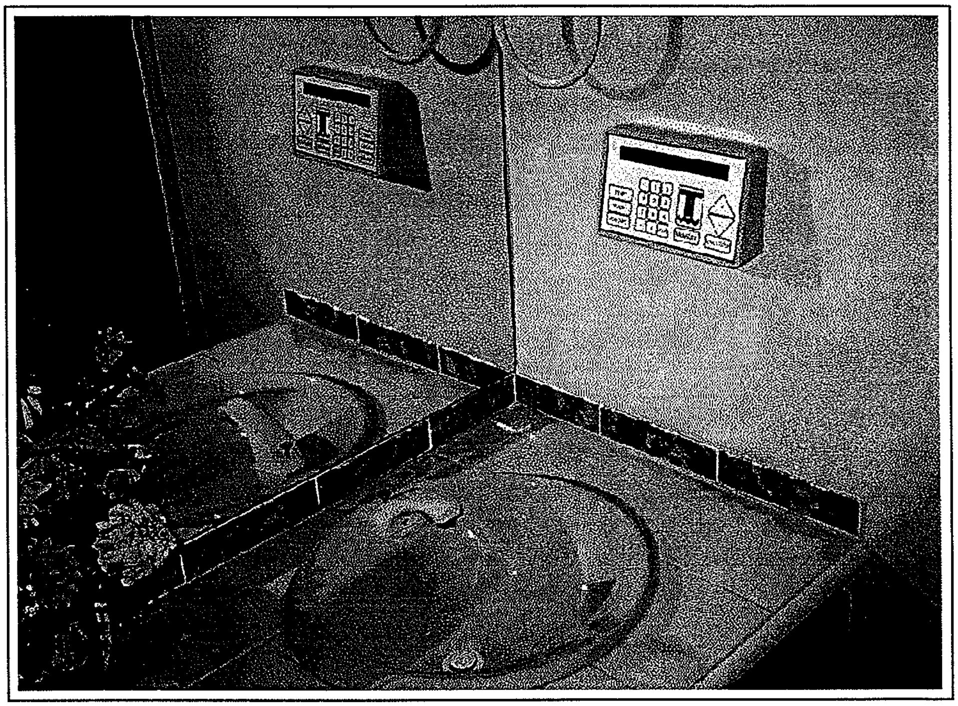
- wood floor is prefinished hardwood, manufactured with water-based adhesives and finishes), and
- ceramic tiles - some glass tiles, some manufactured from recycled glass.

[5] At the time of construction, there were no available CEBus products and components. The design protocols had just been issued at the time this project was getting underway. All systems had to be prototyped, and appliances had to be modified by the systems integrator contractor. The scope of the project was greater than had been anticipated by all concerned.

Plumbing features include:

- low flow faucets and shower-heads,
- 6L flush toilets, including one unit that used a small fan venting directly from the toilet bowl - providing an effective source control of toilet odours.
- computer controlled "touch-Tap" control (Figure 2.7).
- sewage connection to municipal mains is through an aerobic digester, which separates solids that are aerobically decomposed on site. The municipal system therefore only receives liquid waste.

Figure 2.7 Ensuite Bathroom



The computerized tap controls were installed in one shower and one of the double sinks in the ensuite bath, with conventional controls for all other fixtures. The shower control was operated in a demonstration mode during the open house period, but was replaced with conventional taps prior to the sale of the house due to the still uncertain reliability.

Electrical features include:

- the electrical system was designed so that, given a fully functioning home automation system, the house could operate on a 60 amp service (rather than the normal 200 amp service for a house of this size) - reducing the utility's supply requirements, and
- lighting was designed for low energy consumption. All lighting was either low voltage halogen or compact fluorescent.

Site features include:

- planting included a selection of drought tolerant plants to reduce garden water use,
- landscaping included pavers manufactured from recycled auto tires,
- tumbled roman brick pavers were used for walkways. These bricks are porous to rain water, thus reducing the water load on storm sewers,
- site drainage incorporated a mixture of conventinal drain rock and post consumer crushed glass[6]. The drainage layer was laid out under the entire house, and site excavation contoured to a single low point to collect water, thus eliminating the need for a conventional drainage tile around the house perimeter.
- rain water from a portion of the roof is collected in an underground cistern to provide water for garden use. A photovoltaic solar panel charged battery provides power to run the pump to draw water from the cistern, and
- exterior deck was built with a product manufactured from post consumer recycled plastics.

3 CONSTRUCTION OF THE B.C. ADVANCED HOUSE

3.1 Construction Process

Manufacture of prefabricated panels began in January, 1993 and site construction began on March 1, 1993. Construction was substantially complete, with furniture and interior decoration by mid June, 1993 - just in time for the house to be displayed as part of the International Housing Conference in Vancouver.

The entire building envelope was prefabricated off site. Once the foundation was placed on site, the floor and wall panels were brought on site and erected, followed by prefabricated stressed-skin roof panels. This method significantly reduced the site time required for closing the building in - an important factor in the highly variable coastal climate of B.C.. It also meant that a small construction crane had to be used to handle the large prefabricated elements.

Another unconventional aspect of the construction was the drainage system extending under the entire house, which meant that the entire drain bed had to be installed prior to construction of the foundation walls.

A major problem during construction was coordination of trades - in some cases providing 'volunteer' labor. Also, some materials were contributed to the project. In both cases it was difficult to obtain a high priority for either labor or materials when they were being contributed free. In addition, the electrical and automation wiring were installed by trades (volunteered by one of the sponsors) that were not normally active in residential construction - the slow pace of wiring slowed the project by several weeks. Also, some contributors dropped out, resulting in further scheduling problems.

[6] Currently recycling programs are collecting large quantities of green glass, but there is no re-use market in the Lower Mainland of B.C. for the foreseeable future.

Due to time constraints, "in progress" demonstrations of the construction had to be curtailed, and only a few groups were invited. Nevertheless, during the time many trades and neighbours noted that there were unique aspects to the house and many stopped by to view the work.

3.2 Waste Management During Construction

There was reduced waste generated on site, as significant portions of the building were manufactured off site, in a factory environment, so that there was a better control on the use of materials, particularly structural framing materials. However, the work on site was not as carefully monitored.

Drywall constituted the problem. All the off-cuts were separated, and taken to a drywall recycling plant, in accordance with what now is standard practice in the Vancouver area. Unfortunately, due to a shortage of drywallers at the time, the crew that was hired to do the drywall work were not very good, generating more waste than was necessary.

The major on site waste problem was the packaging of materials brought. For example, while the prefinished cedar siding reduces construction waste, the material comes packaged in cardboard.

4 EXPECTED PERFORMANCE

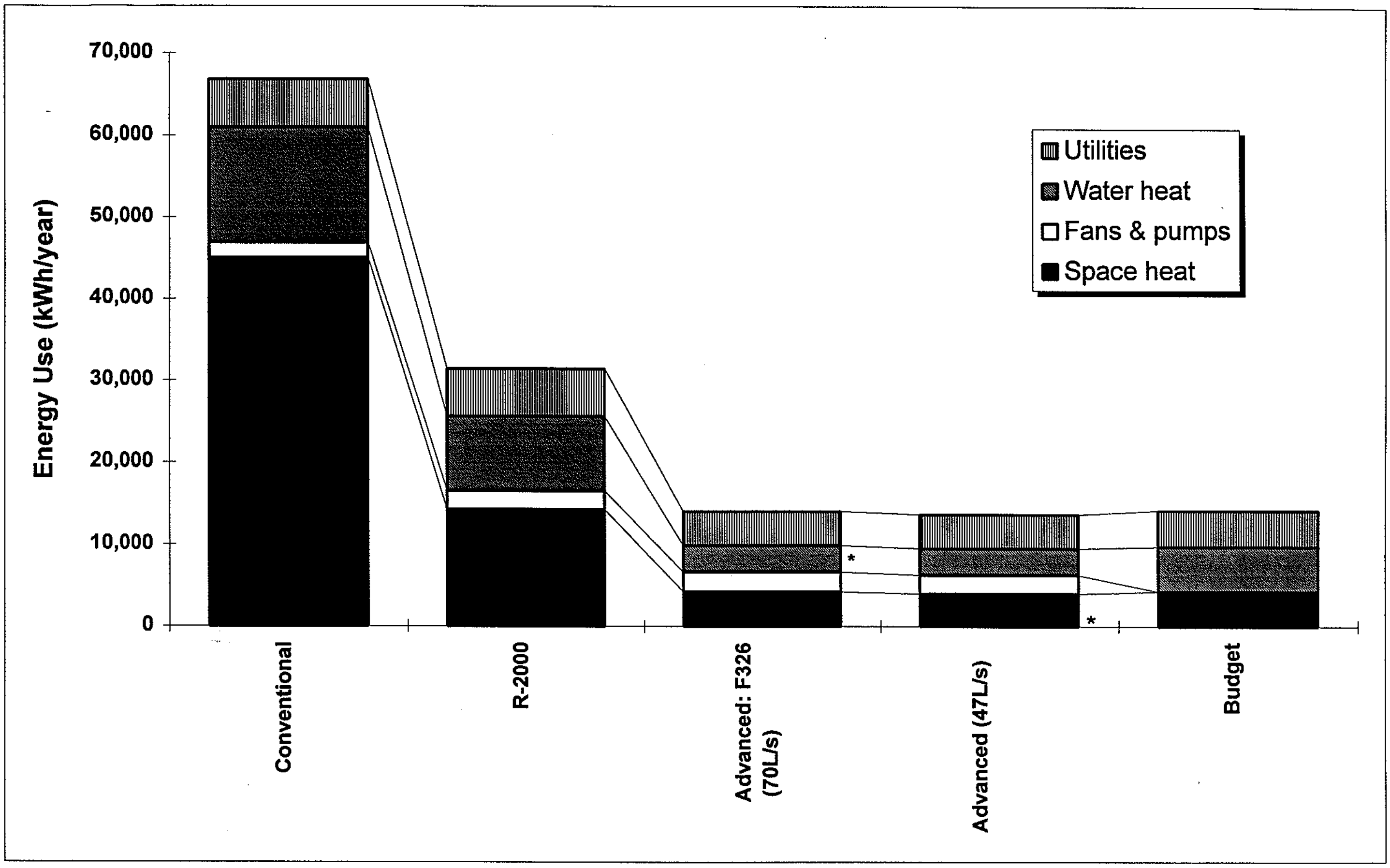
The B.C. Advanced house was able to meet the overall energy budget of 14,167 kWh per year (Figure 4.1) with a predicted energy consumption of 14,072 kWh per year assuming an F326 ventilation rate of 70 L/s (required by the Technical Requirements).

With the four zone ventilation system and occupancy sensors ensuring that ventilation is supplied when and where needed, a lower ventilation rate should be possible. With a more likely ventilation rate of 47 L/s, the total predicted energy consumption was slightly less, at 13,696 kWh per year.

The projected space heating energy of 4,165 kWh per year (based on long-term weather) was slightly less than the budgetted 4,211 kWh - through the use of a high thermal resistance envelope and windows, air-tight construction, high efficiency condensing gas heating system and a high efficiency, double-core heat recovery ventilator. Energy use for utilities, including fans and pumps, was projected at 6,657 kWh per year - far in excess of the budgetted 4,436 kWh. However, projected DHW energy use of 3,250 kWh per year was much less than the budgetted 5,520 kWh due to the use of the active solar system.

Note that no credit was assumed for the buffering effect of the unheated garage, so space heating energy consumption should be slightly less than shown.

Figure 4.1 Expected Performance



House Type	Space Heating Type	Water Heating Type	Ventilation Type	Amount (ac/h)	Total air change (ac/h)	Air Circulation	ENERGY USE Space (kWh)	Fans (kWh)	DHW (kWh)	Utilities (kWh)	TOTAL (kWh)
Conventional	conv. gas	conv. gas	none	0.00	0.33	heat only	45,036	1,839	14,117	5,840	66,832
R-2000	mid-eff. gas	mid-eff. gas	HRV	0.30	0.34	continuous	14,243	2,278	9,084	5,840	31,445
Advanced: F326 (70L/s)	condensing gas	solar + condensing gas	HRV**	0.30	0.33	continuous	4,165	2,453	3,250	4,204	14,072
Advanced (47L/s)	condensing gas	solar + condensing gas	HRV**	0.20	0.23	continuous	3,964	2,278	3,250	4,204	13,696
Budget							4,211	0	5,520	4,436	14,167

Notes: Surface to volume factor = 0.729 Occupancy factor = 0.9

The Advanced F326 run (70 L/s) assumes that the house will be ventilated at 71 L/s - a value determined by the F326 formula. Since the B.C. Advanced house uses vaulted ceilings, its volume is larger than is normal for a house with a similar floor area. The zoned control system also allows for a better distribution of ventilation air. The Advanced (47 L/s) run represents a more likely mode of operation with ventilation exceeding ASHRAE's recommended 15 cfm per person (assuming 6 occupants).

* Water heating requirement for Advanced house is the Total DHW supply minus Solar System supply (about 3,250 kWh)

** Double core HRV

No credit for sheltering effect of garage

The Advanced house uses only 21% as much energy as a conventional house and 44% as much energy as an R-2000 house.

5 MONITORING PROGRAM

5.1 Background

Key to the success of any monitoring project are clearly defined objectives. The details of a monitoring program are driven by these objectives and will determine the depth of the data analysis, the types and frequency of measurements, the monitoring procedures carried out and the sensors, software and hardware employed.

In order for the Program Objectives to be useful in providing direction when defining the Monitoring Program, they must first clearly indicate **who** the audience for the monitored information will be, **why** this information is being collected, and **how** the monitoring program results will be used. The expectations of all those for whom the data is intended must be addressed in order to ensure the usefulness of the results. For example, with regards to providing feed-back on systems performance, it is imperative to know if the audience for this information is the research community, the manufacturer, the builder or the general public. The type and depth of information gathered for each of these groups would be very different.

Therefore, the following process was followed in setting up the monitoring program:

1. establish the monitoring objectives,
2. determine methods of analysis along with measured input requirements to carry out the analysis,
3. define the monitoring system based on measured input requirements,
4. select, acquire and install monitoring equipment and sensors, and
5. commission monitoring system.

5.2 Objectives of Monitoring

The Program Objectives specified by NRCan/CANMET for the Advanced House Monitoring Program were based on the broader objectives finalized in the Advanced House Technical Requirements and are as follows:

- To ensure the successful implementation and reporting of a monitoring program, at least as rigorous as the Level B[7] approach used in the R-2000 Program,

[7] Originally, the Level B method of monitoring was used in the SERI program in the U.S. and in the NRC Solar Energy Program. Briefly, Level C monitoring consists of reading sub-meters on a monthly basis, with only minimal knowledge of what is happening inside the house; Level B monitoring typically uses a computer-based system to monitor conditions inside and outside the house, as well as to monitor energy use of various sub-systems; and Level A monitoring goes beyond Level B to monitor conditions inside various sub-systems in an attempt to understand their operation. The monitoring program used in the B.C. Advanced House, while primarily Level B, had elements of Levels A and C as well.

- To verify the compliance of the Advanced House with the program's Technical Requirements and with other specific performance targets,
- To provide feedback to manufacturers, builders and researchers on the performance of the innovative products and systems installed in the Advanced Houses,
- To provide feedback on occupant's attitudes towards, and satisfaction with, features employed in the Advanced House,
- To provide feedback on the media visibility and general public response for the Advanced House,
- To provide sufficient data to support the development of new standards, as required, for the new technologies,
- To provide sufficient data to assist in improving and enhancing the capabilities of the HOT-2000 Program to take into account these new technologies,
- To build and enhance on the national database of building performance originally developed for the R-2000 Program,
- To evaluate the impacts of the innovations on occupant lifestyle with respect to health, energy savings comfort and maintenance,
- To verify the benefits of new technologies and designs so these can be incorporated into the R-2000 Program, and
- To allow for the evaluation of the cost-effectiveness of new products and systems.

These objectives directed the process of defining the Monitoring Program which was established by the Advanced Houses National Monitoring Coordinating Team[8].

The objectives werre summarized in a monitoring plan (see Appendix A).

5.3 Design of Analysis Software

Customized, spreadsheet-based software was produced for the B.C. Advanced house (see Appendix D) by SAR engineering ltd.. The software allowed each month's hourly data to be processed to produce daily and monthly summaries for submission to NRCan.

The analysis software was developed, using Microsoft Excel (version 4.0) linked spreadsheets. All of the hourly data was input into this set of spreadsheets for analysis and graphing.

After checking the results and putting in comments, the results were output as monthly reports (see Appendix D). If necessary, questionable data was deleted, and calibration factors (based on manual meter readings) input as required.

[8] Wil Mayhew, HME and Ken Cooper, SAR engineering ltd.

The results were linked to provide the summary outputs used in this report. Monthly summaries of utilities energy use, inside temperature, outside temperatures and horizontal insolation were determined and input to HOT-2000 for a series of calibrated simulations to determine energy balances.

5.4 Monitoring System Design

The monitoring system design was carried out by the National Monitoring Team, in consultation with the local monitoring coordinator. This ensured that the results from all the Advanced Houses would be compatible, and would also simplify the design of the analysis software.

The monitoring system used a combination of continuous, computerized data acquisition system (DAS) based monitoring, monthly manual meter readings, and short term tests.

5.5 Monitoring Implementation

5.5.1 CONTINUOUS MONITORING:

Figure 5.1 Data Acquisition System

Monitoring of the B.C. Advanced House was based on the "Level B" approach developed for the R-2000 Program. In this approach, data collection addresses issues of energy use, occupancy, ventilation and air quality, performance of mechanical systems and the building envelope, and environmental concerns. A combination of continuous, short-term and manual measurements were used to obtain the required data.

The basis of Level B monitoring is to measure house parameters in sufficient detail so as to derive a heat balance for the house such that all losses and all energy inputs are characterized.

Analysis of the heat load for a house includes calculating heat losses associated with above grade components (ceilings, walls, windows, floor), infiltration and mechanical ventilation. Space heating gains are made up of three principal components - free heat generated from appliances and occupants, passive solar gains, and purchased space heat.

The space heating consumption for this house was put into context with respect to other loads in the house, including domestic hot water energy consumption, and base electric energy consumption (lights and appliances). The performance of two specific sub-systems, the domestic hot water and ventilation systems, were also examined.

The indoor air quality performance of this house was examined through analysis of over one year's worth of data with respect to indoor temperatures, relative humidity and carbon dioxide concentration.

A computerized data logger[9] was set up in the house to automatically collect data from a variety sensors.

Error checking and preliminary processing were performed on the data and the results stored hourly.

In order to assess the performance of the houses a number of parameters were measured on a continuous basis using a data acquisition system. The monitoring software package called CO-PILOT was used to manage the collection of all the raw data, provide error checks and produce preliminary on-line results. Data was typically collected at from 5 second to 60 second intervals and accumulated into hourly averages or sums. Data collected included:

- on-time of specific mechanical systems and sub-systems,
- energy consumption (electricity and natural gas),
- electrical consumption of selected mechanical equipment (i.e. fans, pumps),
- water flows and temperatures,
- solar radiation,
- indoor and outdoor ambient temperatures,
- relative humidity, and
- carbon dioxide concentration

5.5.2 MANUAL METERS:

Monthly values of the following were collected:

- gas energy use, broken down by end use -
  - total
  - space and DHW
  - stove
  - dryer
  - outside (barbeque)
- outside electrical energy use,
- water use, broken down by end use -

[9] Sciemetric data acquisition system, in conjunction with an MS-DOS computer.

- total
- total hot
- outdoor

Total electrical, gas and hot water readings were used to check the hourly logged values and to generate calibration factors for the hourly data.

5.5.3 SPOT TESTS:

Spot values were required for the following:

- indoor air quality (one week test)-
  - formaldehyde
  - volatile organic compounds (total)
  - radon
  - particulates
- air-change rate (concurrent with indoor air quality test)
- fan depressurization air-tightness test (tests upon completion of construction and upon completion of open house period)
- air flow rates (circulation, HRV, stove exhaust); also by outlet

6 MONITORED RESULTS

The results presented in this report cover the B.C. Advanced House from the outside to inside, from general to more detailed. The report begins by describing the conditions around and inside the house.

The summary tables and figures in this report reference summary tables in Appendix C, which in turn reference the processed hourly data.

6.1 Monitoring Status

The B.C. Advanced House was monitored, in an unoccupied condition, from 1 July, 1994 through 31 August, 1995. The analyzed data in this report covers the period from September, 1994 through August, 1995. Hourly data is essentially complete, except for the following:

- October 6 to November 2, 1994,
- January 19 to February 1, 1995,
- February 8 to March 1, 1995, and
- July 18 to August 2, 1995.

Data from manually read meters is available for the entire period (readings taken approximately the first of each month).

6.2 Environment

6.2.1 Outdoor Conditions

In order to relate the monitored performance of the B.C. Advanced House to long-term performance, the outdoor conditions for the monitored period were compared to long-term values (see Table 6.1).

From September, 1994 to August, 1995, the house site averaged 5% more heating Degree Days (base 18C) than at Vancouver International Airport (the house site totalled 2,876 Degree Days versus 2,736 at the airport - both less than the long-term 3,002). Therefore, long-term average space heating requirements will be slightly higher than for the monitored year.

With the exception of a relatively cool November, all the months from October through April were slightly warmer than long-term.

Annual site measured horizontal insolation averaged 8% less than long-term for Vancouver (October to April: 7% less than long-term). Therefore long-term average solar gains should be slightly higher than for the monitored period.

October through April airport winds averaged 7% higher than long-term (winds were not measured at the house site). Therefore, long-term average infiltration should be slightly less than for the monitored period.

Overall, the monitored period was quite representative of long-term conditions.

Table 6.1

OPERATING CONDITIONS:

B.C. Advanced House

House unoccupied for entire period

	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr	YEAR	Remarks
Outside Temp.: Avg. (C)	15.6	17.6	19.2	16.3	16.1	12.4	4.4	3.9	3.1	7.0	7.2	10.2	17.0	6.9	11.1	
Hourly Minimum (C)	5.1	9.7	10.9	9.7	9.1	6.7	-2.7	-7.0	-5.4	1.8	-2.7	1.9	5.1	-7.0	-7.0	min.
Hourly Maximum (C)	26.8	32.5	31.8	27.1	25.7	19.7	10.5	12.1	10.0	13.3	20.9	22.7	32.5	22.7	32.5	max.
Site Degree Days (18C)	107	68	33	220	85	178	407	436	462	308	335	237	513	2,363	2,876	at site
Airport Degree Days (18C)	119	57	12	53	71	242	391	423	419	356	339	254	312	2,424	2,736	Vancouver Int'l (1994-95)
Long-term Airport Deg.Days (18C)	183	89	40	36	113	249	360	451	466	376	363	276	461	2,541	3,002	Vancouver Int'l (1960-90)
Inside Temperature: Avg. (C)	23.3	22.1	24.2	21.5	24.2	23.9	17.7	17.6	17.8	19.7	20.0	20.8	23.1	19.6	21.1	
Hourly Minimum (C)	15.1	17.1	19.4	15.7	20.2	21.9	14.5	13.4	13.8	16.8	13.9	16.5	15.1	13.4	13.4	min.
Hourly Maximum (C)	29.7	32.6	31.6	30.8	31.7	27.6	23.3	24.3	22.7	25.9	26.9	28.6	32.6	28.6	32.6	max.
Inside Temp. Completeness	*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	
Master bedroom Temp. (C)	24.7	23.8	25.9	23.4	24.9	24.6	17.5	17.3	17.5	19.4	20.5	21.6	24.5	19.8	21.8	
Living room Temperature (C)	23.6	22.7	24.7	22.3	24.0	24.0	17.2	16.9	17.2	19.3	20.0	20.8	23.5	19.4	21.1	
Family room Temperature (C)	23.1	21.1	23.1	19.9	25.2	24.3	18.2	17.7	17.9	20.1	20.6	21.5	22.5	20.0	21.1	
Space Temp. Completeness	*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	
Living: Avg. Temp. swing (C)	2.6	2.7	2.6	2.5	2.9	3.5	2.0	1.8	2.2	2.7	3.1	2.8	2.7	2.6	2.6	
Minimum Temp. swing (C)	1.3	1.1	0.5	0.7	1.0	1.0	0.3	0.3	0.1	0.2	0.9	0.9	0.5	0.1	0.1	min.
Maximum Temp. swing (C)	3.7	4.0	3.7	4.1	5.0	4.7	7.5	5.1	5.0	7.5	6.9	4.2	5.0	7.5	7.5	max.
SE bdrm. Temp. swing (C)	2.2	2.3	2.3	2.1	2.1	2.4	1.4	1.7	2.3	2.0	2.4	2.0	2.2	2.0	2.1	
Crawlspace temperature (C)	14.6	16.4	18.0	17.4	17.6	16.4	11.9	10.0	9.2	10.7	10.4	11.7	16.8	11.5	13.7	
Garage temperature (C)	15.7	17.6	19.6	18.8	19.0	16.6	10.7	8.5	7.4	9.6	9.6	11.6	18.1	10.6	13.7	
Inside RH: Avg. (%)	45%	55%	55%	61%	56%	40%	44%	41%	39%	45%	39%	41%	54%	41%	47%	
Hourly Minimum (%)	34%	35%	42%			35%	39%	34%	33%	41%	28%	35%	34%	28%	28%	min.
Hourly Maximum (%)	58%	73%	72%			42%	49%	51%	45%	52%	50%	46%	73%	52%	73%	max.
Family rm. CO_2: Avg. (ppm)	417	425	436	442	409	413	412	396	411	457	419	406	426	416	420	
Hourly Minimum (ppm)	391	398	398	403	360	375	348	368	361	397	369	384	360	348	348	min.
Hourly Maximum (ppm)	562	550	529	582	626	465	651	661	828	743	744	511	626	828	828	max.
CO_2 Completeness	*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	*Inside CO_2 only*
Air quality Completeness	*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	*CO_2, RH*
Stack & wind Infiltration (ac/h)	0.071	0.062	0.072	0.057	0.051	0.050	0.101	0.085	0.070	0.049	0.078	0.067	0.06	0.07	0.07	AIM2 model
Balanced Ventilation (ac/h)	0.213	0.214	0.213	0.212	0.089	0.090	0.086	0.084	0.085	0.089	0.193	0.220	0.19	0.12	0.15	
Total: Infiltration + Ventilation (ac/h)	0.295	0.280	0.287	0.271	0.152	0.148	0.198	0.179	0.166	0.149	0.285	0.301	0.26	0.20	0.23	includes unbalanced fans

6.2.2 Buffer Space Temperatures

Temperatures were monitored in the unheated crawlspace and in the unheated garage. These are shown in Tables and Figures in Appendix B.

The unheated crawlspace average 11.5 C from October through April - ranging from a low of 8.2 C in January to a high of 16.9 C in October. HOT-2000 predicted temperatures averaged 4.1 C lower than measured for the same period.

The unheated garage averaged 10.6 C from October through April - ranging from a low of 5.2 C in January to a high of 19.0 C in October. The buffering effect of the garage reduced heat loss through the common door, wall and floor by an average of 18% for the same period.

6.2.3 Indoor Temperatures

Inside temperature statistics are summarized in Table 6.1 - including space-weighted composite inside temperatures, room temperatures, room diurnal temperature swings, crawlspace temperatures and garage temperatures.

Since the house was unoccupied, temperatures are probably atypical. Winter temperatures averaged only 19.6 C[10]. The high summer temperatures (averaging 23.1 C, but with hourly maxima as high as 32.6C) are due to the fact that the cooling system was not connected to the CEBUS system, with only a manual control available.

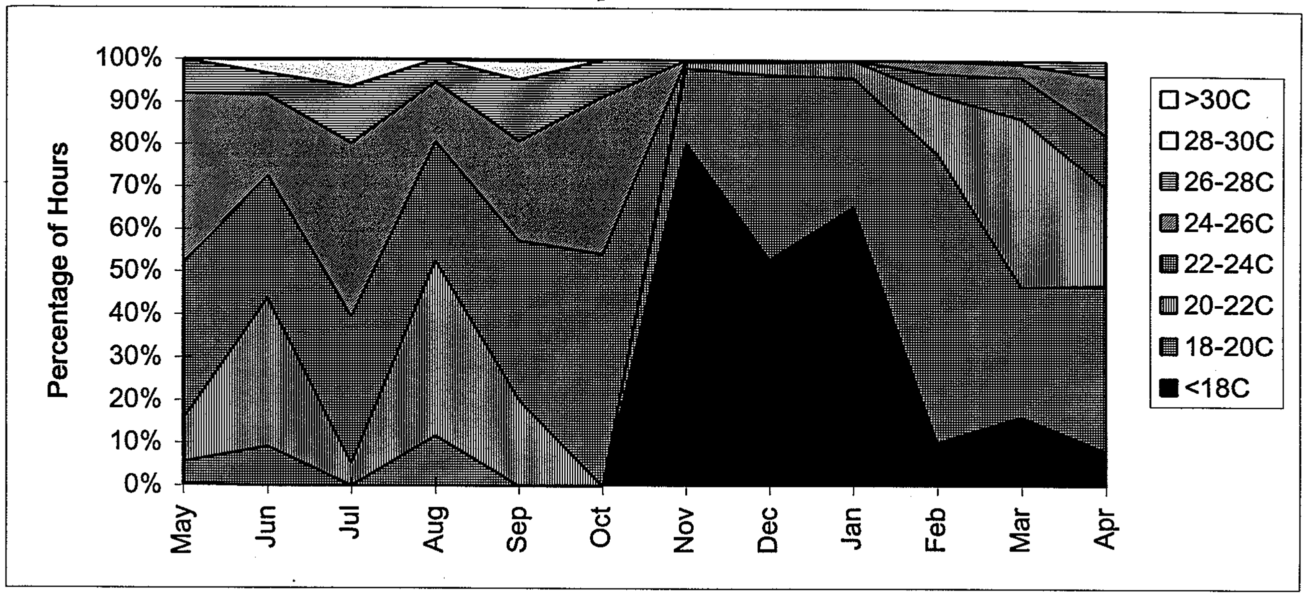
Frequency histograms (graphs and tables) are shown in Figures 6.1 and 6.2 for the living room and ground floor master bedroom, respectively. The figures show the percentage frequency of hours within each temperature band. The tables also show the average temperature for the period, as well as the extreme minima and extreme maxima. At the bottom of each table are values that indicate the completeness of the data, as a percentage.

For the period from May to September (summer) , the living room temperature (Figure 6.1) was between 18C and 24C for 49% of the monitored hours. The ground floor master bedroom temperatures (Figure 6.2) were in the same temperature range for 44% of the hours, with temperatures greater than 24C for 56% of the hours. The master bedroom is located on the southwest corner of the house with windows facing south and a patio door facing west.

For the period from October to April (winter), the the living room temperature was between 18C and 24C for 57% of the monitored hours, with temperatures less than 18C for 33% of the hours. The ground floor master bedroom temperatures were in the same temperature range for 56% of the hours, with temperatures less than 18C for 30% of the hours. The low temperatures were due to the house being unoccupied - extreme thermostat setback combined with minimal internal gains.

[10] Normal winter temperatures are about 21 C [3]

Figure 6.1 B.C. Advanced House: Living room temperature

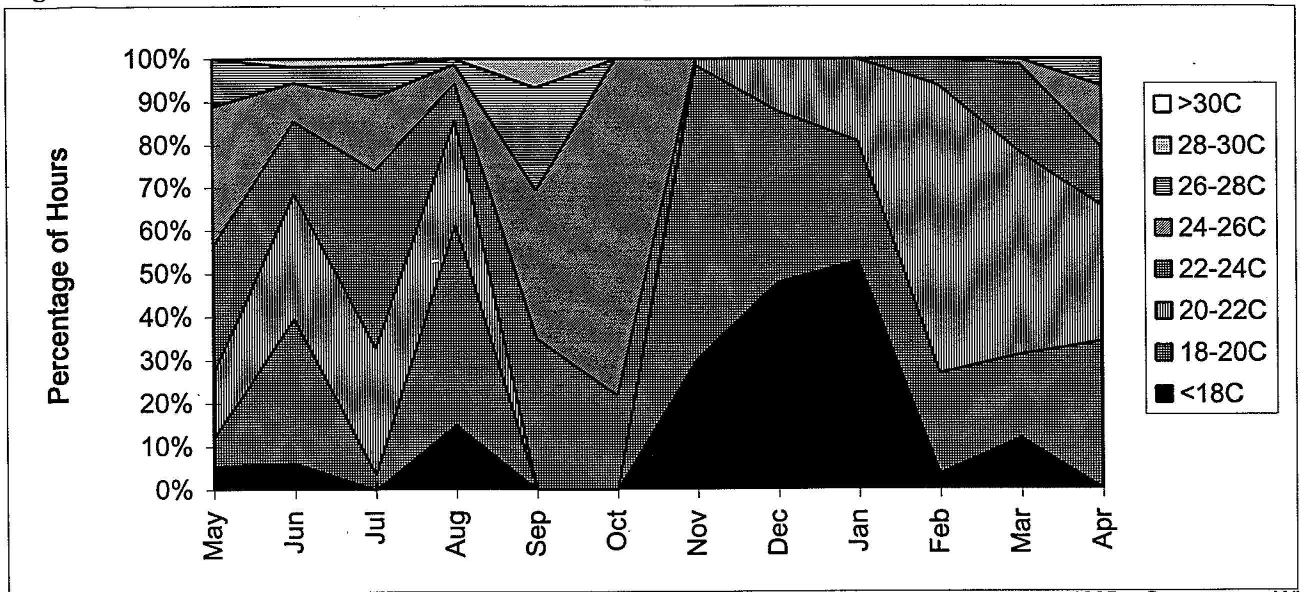


Temperature (C):		1995		1995	1994			1994	1995			1995	Summer	Winter
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
Average	23.6	22.7	24.6	22.2	23.9	24.0	17.2	16.9	17.2	19.5	19.9	20.8	23.4	19.4
Minimum	17.8	18.9	21.1	19.0	20.2	22.2	14.6	13.4	13.8	16.8	14.6	17.0	17.8	13.4
Maximum	26.9	30.0	29.7	27.8	30.2	27.6	23.3	22.3	20.5	25.9	26.5	27.1	30.2	27.6

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<18C	0%	0%	0%	0%	0%	0%	81%	53%	66%	10%	16%	8%	0%	33%
18-20C	5%	9%	0%	12%	0%	0%	17%	43%	30%	68%	30%	39%	5%	33%
20-22C	10%	35%	5%	41%	20%	0%	2%	3%	4%	14%	40%	23%	22%	12%
22-24C	36%	29%	34%	28%	37%	54%	0%	0%	0%	5%	10%	12%	33%	12%
24-26C	40%	19%	41%	14%	23%	37%	0%	0%	0%	3%	3%	13%	27%	8%
26-28C	8%	5%	13%	5%	15%	9%	0%	0%	0%	0%	1%	4%	9%	2%
28-30C	0%	3%	6%	0%	4%	0%	0%	0%	0%	0%	0%	0%	3%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Figure 6.2 B.C. Advanced House: Master bedroom temperature

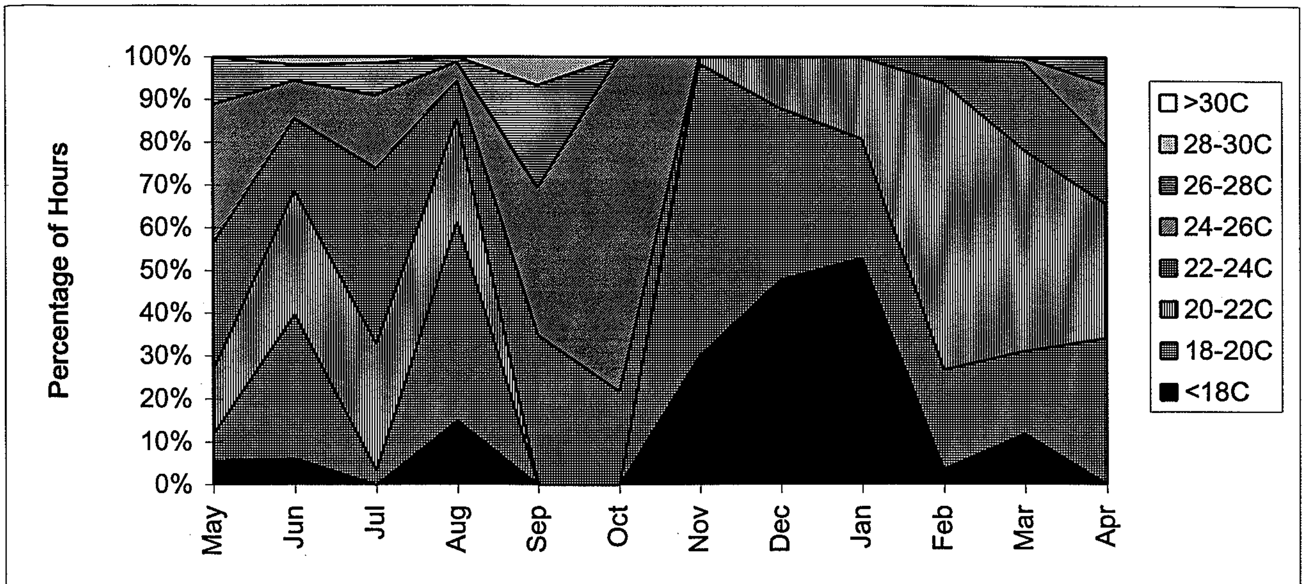


	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr
Average	24.7	23.8	25.7	23.3	24.8	24.6	17.5	17.3	17.5	19.5	20.4	21.6	24.5	19.8
Minimum	19.1	20.0	22.3	20.1	21.3	22.7	15.0	13.9	14.3	17.1	15.2	17.6	19.1	13.9
Maximum	29.7	32.6	31.6	30.8	31.7	27.5	21.2	21.7	20.2	24.2	26.9	28.6	32.6	28.6

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<18C	0%	0%	0%	0%	0%	0%	71%	51%	62%	10%	13%	2%	0%	30%
18-20C	2%	0%	0%	0%	0%	0%	27%	44%	32%	63%	22%	32%	0%	31%
20-22C	6%	29%	0%	34%	4%	0%	2%	5%	7%	21%	45%	28%	15%	15%
22-24C	27%	28%	17%	33%	39%	37%	0%	0%	0%	4%	14%	16%	29%	10%
24-26C	41%	25%	47%	18%	30%	46%	0%	0%	0%	1%	5%	15%	32%	9%
26-28C	18%	10%	21%	11%	20%	17%	0%	0%	0%	0%	1%	7%	16%	4%
28-30C	5%	5%	11%	4%	6%	0%	0%	0%	0%	0%	0%	1%	6%	0%
>30C	0%	3%	4%	1%	2%	0%	0%	0%	0%	0%	0%	0%	2%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Figure 6.3 B.C. Advanced House: HRV exhaust relative humidity



	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr
Average	45	55	55	62	56	40	44	41	38	45	39	41	54.4	41.3
Minimum	34	35	42	47	46	35	39	34	33	41	28	35	34.0	28.0
Maximum	58	73	72	76	77	42	49	51	45	52	50	46	77.0	52.0

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20-30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	1%
30-40%	5%	2%	0%	0%	0%	30%	8%	25%	46%	0%	36%	26%	1%	24%
40-50%	77%	28%	14%	2%	4%	70%	92%	74%	54%	97%	57%	74%	25%	74%
50-60%	18%	38%	70%	39%	76%	0%	0%	1%	0%	3%	0%	0%	48%	1%
60-70%	0%	31%	14%	46%	18%	0%	0%	0%	0%	0%	0%	0%	22%	0%
70-80%	0%	1%	1%	13%	2%	0%	0%	0%	0%	0%	0%	0%	4%	0%
>80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Living room temperature swings averaged 2.6 C (Table 6.1) - but ranged as high as 7.5 C. The large temperature swings are due to a combination of large south glazings, low inside temperatures and the lack of occupants to control the temperatures.

Due to the continuous air circulation, there was very little difference in temperature between zones - typically less than 1.0 C in winter. The differences were larger in summer - with the overheating master bedroom averaging 3.5 C warmer than the north-facing family room in July.

6.2.4 Indoor Relative Humidity

The HRV exhaust relative humidity (collecting from kitchen and bathrooms) averaged 54% in summer and 41% in winter, ranging from a low of 28% in winter to a high of 73% in summer (see Figure 6.3). By comparison, the smaller CMHC Healthy House in Vancouver averaged 52% in summer and 40% in winter with three occupants [6].

6.2.5 Indoor Air Quality

Carbon dioxide concentration in the family room averaged just over 400 ppm, summer and winter (see Figure 6.4). Concentrations were in the range from 350ppm to 450ppm for 92% of the monitored summer hours (data 90% complete) and 87% of the winter hours (data 70% complete). These values are likely not typical of occupied conditions, which usually average over 500 ppm [3].

One week tests for indoor air quality were performed - one test in February, 1994/March, 1994 and another in March, 1995. The results are shown in Table 6.2. Both tests show formaldehyde concentrations well below the health & welfare goals of 0.05 ppm.

Concentrations of total volatile organic compounds (TVOC) for the two tests were 0.33 mg/m^3 and 0.05 mg/m^3 - both well below the average for 571 conventional Canadian houses[11] of 0.57 mg/m^3.

Approximate concentrations with 0.30 air changes per hour are also shown in Table 6.2, since concentrations should only be compared if ventilation rates are the same. Under these 'normalized' conditions, the average formaldehyde concentration would equal the 0.05 ppm guideline, and the second test showed a decrease of over 50% from the initial value - in part due to aging and also due to the removal of furniture prior to sale. Under these conditions, the TVOC concentration of 0.80 mg/m^3 would be well above the European guideline.

Perfluorocarbon (PFT) tests were also performed in order to determine overall air change rates during the tests. The initial test result of 0.73 air changes per hour may be somewhat high (HRV spot flow plus calculated infiltration resulted in an average total of only 0.39 air changes per hour). A lower value of air change would result in a reduction in concentrations under the 'normalized' conditions. The second PFT test, at 0.24 air changes per hour is in closer agreement with the hourly monitored average values of 0.20 air changes for HRV flow and 0.33 air changes for

[11] from a compilation of several surveys: *"Indoor Air Quality and Ventilation Rates in R-2000 Houses"* by T. Hamlin and J. Gusdorf [7]

total calculated ventilation rate (including infiltration and unbalanced fans).

Overall formaldehyde source strengths were determined from the following relationship:

$$S = C \times V \times ac$$

S = source strength (mL/h)
C = pollutant concentration (ppm)
V = house volume (m^3)
ac = PFT determined air change rate (h^{-1})

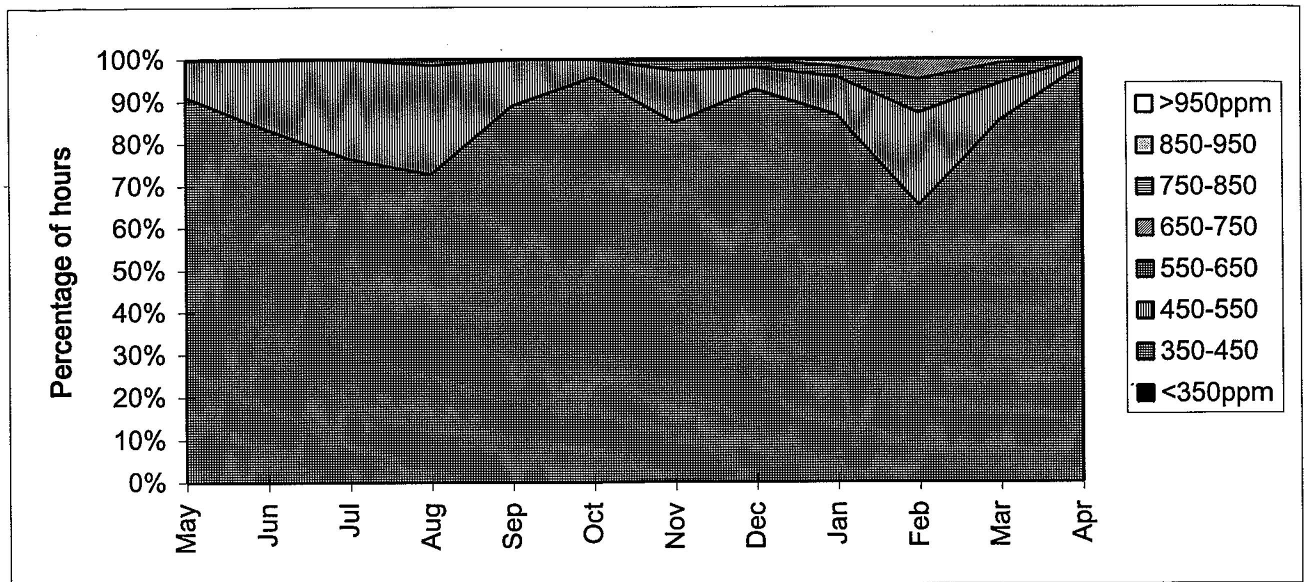
The January, 1994 whole house formaldehyde source strength of 12.6 mL/hour was higher than the average of about 5 mL/hour for the NRCan Advanced houses [2] for approximately the same time after construction. It was, however, lower than the 17 mL/hour found typical for new houses in B.C. in 1989[12]. By March of 1995, the overall source strength had dropped to only 3.4 mL/hour.

Table 6.2 Indoor Air Quality Test Results

		Units	Test period 28-Feb-94 to 4-Mar-94	Normalized to 0.30 ac/h	Test period 7 Mar-95 to 14 Mar-95	Normalized to 0.30 ac/h
Test Conditions	Occupants		Unoccupied		Unoccupied	
	Outside temp.	C	2.0		7.9	
	Living room temp.	C	21.2		20.2	
	M. bedroom temp.	C	17.8		20.6	
	Relative humidity	%	31			
Concentrations:						
TVOC	living room	mg/m³	0.330	0.803	0.050	0.040
Formaldehyde	master bdrm	ppm	0.013	0.032	0.017	0.014
	dining room	ppm	0.028	0.068	N/A	N/A
Particulates	living room	ug/m³	5	12	7	6
Air Change Rate:						
Volume		m³	844		844	
Air change rate	(PFT)	ac/h	0.73	0.30	0.24	0.30
	Balanced vent.	ac/h	0.28 (spot test)		0.20 (DAS)	
	Vent. + Infiltration	ac/h	0.39 (calculated)		0.33 (calculated)	
Source Strength:						
Formaldehyde	master bedroom	mL/h	17.2		N/A	
	living room	mL/h	8.0		3.4	
Average		mL/h	12.6		3.4	

[12] Results of survey of ten conventional houses built in 1989. Personal communication from Tom Hamlin, NRCan.

Figure 6.4 B.C. Advanced House: Family room carbon dioxide concentration



					unoccupied for entire period							Summer	Winter
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
Average	417	425	433	441	408	407	412	395	412	460	419	406	425	416
Minimum	391	398	398	403	360	375	348	368	361	397	369	384	360	348
Maximum	562	550	529	582	626	465	651	661	828	743	744	511	626	828

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<350ppm	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
350-450	91%	83%	76%	73%	89%	96%	85%	93%	87%	65%	85%	98%	83%	87%
450-550	9%	17%	24%	26%	11%	4%	12%	5%	9%	22%	9%	2%	17%	9%
550-650	0%	0%	0%	1%	0%	0%	3%	2%	2%	8%	5%	0%	0%	3%
650-750	0%	0%	0%	0%	0%	0%	0%	0%	1%	5%	1%	0%	0%	1%
750-850	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
850-950	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
>950ppm	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total hrs.	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

6.2.6 Simulated Occupancy Test

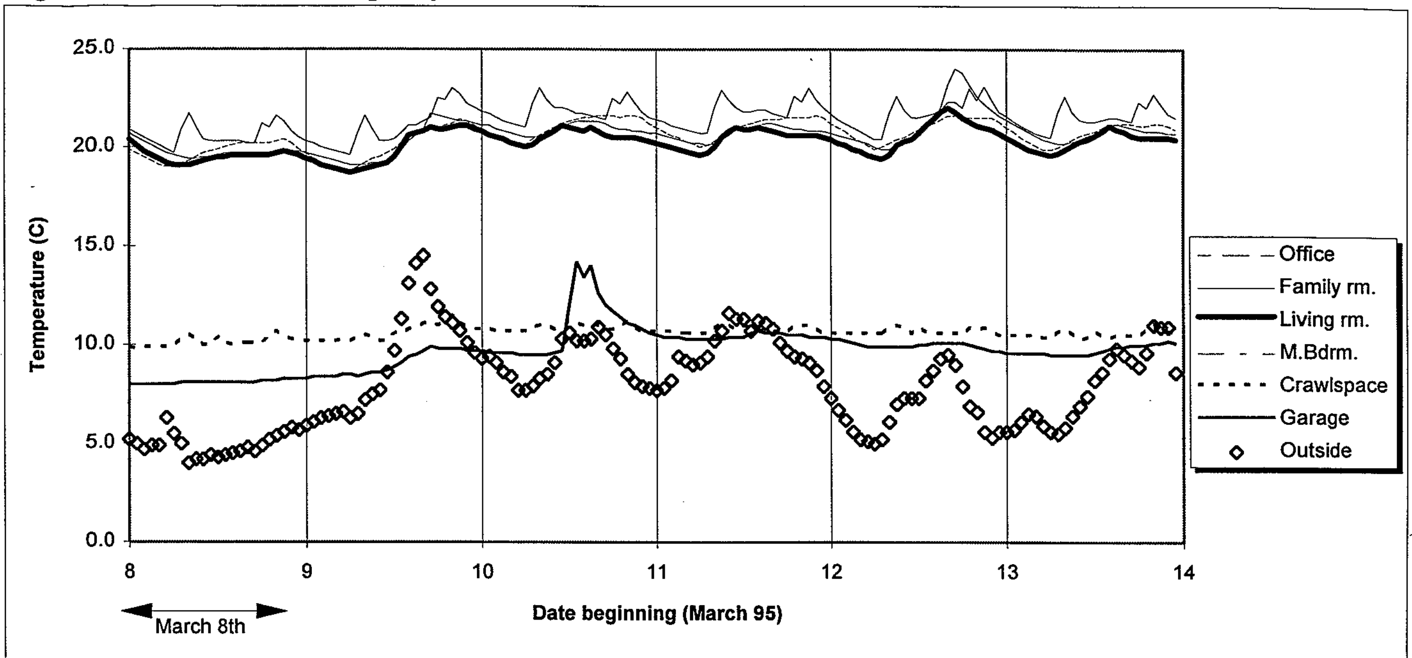
The house was unoccupied during the entire monitoring period. In order to determine how the house would operate when occupied, we performed a six day test in March, 1995 with simulated occupancy.

The CEBUS control system was used to change heating set-points in each of the four zones, and also to control the zone dampers to simulate occupancy in each zone according to a set schedule (see Appendix A.4). CEBUS also controlled the radiant zone valves and circulation pump to supply radiant according to a schedule. An 837 W CEBUS controlled electric heater in the family room, along with a 120 W timer-controlled light in the office were used to bring base load energy usage up to 'normal' levels. The CEBUS controlled dishwasher was run on a series of rinse cycles to simulate hot water usage. Indoor and outdoor lighting were uncontrolled - operated randomly by the real estate agent, prospective buyers, etc.

During this period:

- hot water use averaged 215 L/day,
- inside electrical energy use averaged 22.6 kWh/day (20.2 kWh/day not including monitoring equipment - 11% more than in original projections) -
  - 2.4 kWh/day for monitoring system,
  - 5.8 kWh/day for pumps and fans, and
  - 14.4 kWh/day for general utilities (lights, refrigerator and CEBUS-controlled loads)
- inside temperature averaged 20.5C (bedroom zone thermostat set to 18C, other zones to 21C from 6AM to 10PM, otherwise 18 C (approximately equal to 21 C used in original projections),
- ventilation averaged 0.2 ac/hr (equal to low ventilation projection, but less than F326 requirement of 0.3 ac/hr),
- outside temperature averaged 2.5 C warmer than long-term for March,
- airport winds averaged 38% stronger than normal, and
- rainfall occurred on most days, with sunny periods on March 12th.

Figure 6.5 Simulated Occupancy Test - Conditions



Temperatures:	1st floor			2nd floor		Weighted	Difference from living room:				Note:
	Living rm. (C)	Family rm. (C)	M.bdrm. (C)	SE bdrm. (C)	Den (C)	Average (C)	Family rm. (C)	M.bdrm. (C)	SE bdrm. (C)	Den (C)	Family room warmer than other rooms due to heater supplying "internal gains" located in that room
Average	20.2	21.4	20.6	20.3	20.6	20.5	1.18	0.37	0.06	0.36	
Minimum	18.7	19.6	19.1	18.6	18.7		0.10	-0.30	-0.50	-0.50	
Maximum	22.0	23.1	24.0	21.5	21.6		2.70	2.30	0.50	1.10	

The heating system maintained average room-to-room temperature differences of less than 0.4C (table above), except for the family room where a CEBUS-controlled heater drove temperatures up whenever it came on. Some overheating in the master bedroom due to afternoon solar gains (Figure 6.6). In spite of having an 18 C setpoint in the bedrooms during the day, temperatures generally tracked the other zones (air flow was reduced, but not shut off to the bedrooms during the day)

Figure 6.6 Simulated Occupancy Test - March 12th Conditions

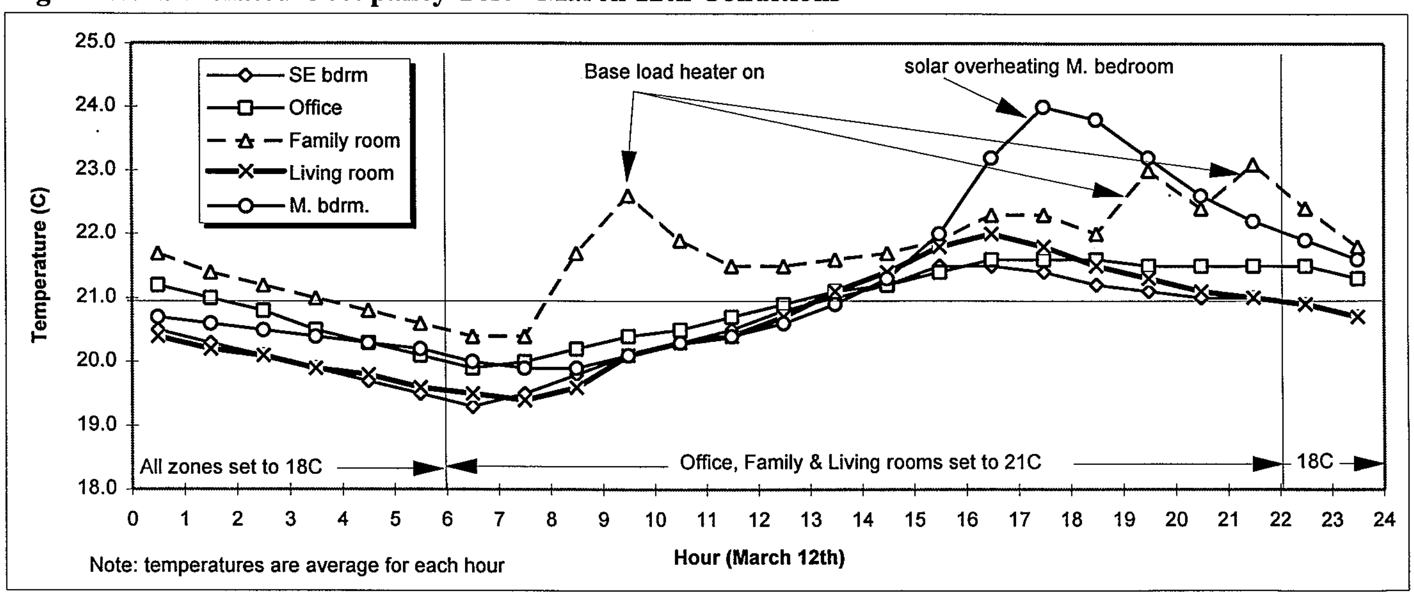


Table 6.3 Simulated Occupancy Test - Systems

Dishwasher on rinse cycle supplied simulated hot water use (under CEBUS control)
Utilities supplied by refrigerator, lights (uncontrolled) plus controlled loads in family room (837W) and den (120W)
Outside loads supplied by uncontrolled lights

Mechanical Systems:	Hot water system Demand (L)	Hot temp. (C)	Water tank efficiency (%)	Pumps & fans (kWh/d)	Utilities (kWh/d)	Outside (kWh/d)	Total Electrical (kWh/d)	Gas Space + DHW (kWh/d)	HRV exhaust (L/s)	Imbalance (%)	Sensible efficiency Core (%)	System (%)
8-Mar-95	219	44.5	96%	5.8	17.1	3.2	28.5	40.5	46	17%	75%	72%
9-Mar-95	209	44.3	104%	5.8	17.2	3.8	29.1	39.2	47	16%	75%	72%
10-Mar-95	219	44.6	114%	5.7	15.8	4.6	28.5	32.0	47	16%	76%	72%
11-Mar-95	211	44.4	83%	5.7	11.9	2.9	22.9	30.9	46	16%	75%	72%
12-Mar-95	222	44.3	91%	5.8	12.1	1.8	22.0	32.3	46	17%	76%	72%
13-Mar-95	208	44.4	90%	5.8	12.3	1.8	22.3	34.2	47	16%	75%	72%
	215	44.4	97%	5.8	14.4	3.0	25.6	34.8	47	16%	75%	72%
				utilities + fans:	20.2				0.20 ac/h			
Projected			94%		18.2	0.5			0.20 ac/h		84% (0 C)	
Budget:			no allowance for pumps and fans:		12.1	0.5			0.30 ac/h			

Water tank efficiencies (Table 6.3) are approximate due to small temperature differences in the space heat coil, but do indicate that the system, under normal loads, operated at close to specification. Total Electrical (Table 6.3) also includes 2.4 kWh per day of monitoring system load. The heat recovery ventilator operated somewhat below the 0 C test efficiency of 84% - probably due to being 16% out of balance (supply exceeded exhaust). Some space heating is present for all hours (Figure 6.7) due to timer-controlled circulation through the fan-coil to prevent stagnant water mixing with potable water in the tank (health codes). Without the buffering effects of the garage and crawlspace (Table 6.3), total losses would have been 5% higher.

Figure 6.7 Simulated Occupancy Test - March 12th Power Profile

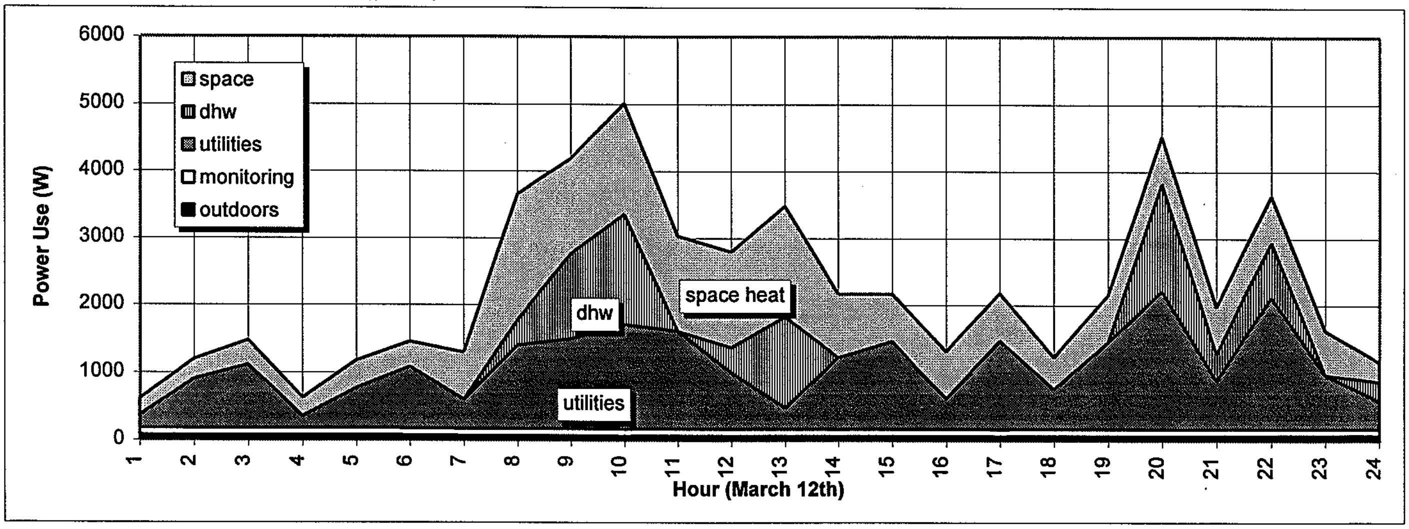


Table 6.4 Simulated Occupancy Test - Energy Balance

	Appl. (kWh/d)	Ventil. (kWh/d)	Space (kWh/d)	Solar Loss - Gain (kWh/d)	Foundation (kWh/d)	Abv. Fdtn. (kWh/d)	Infil.+Ventil. (kWh/d)	Humidification (kWh/d)	Total Losses (kWh/d)	gar. & c/s Buffering (kWh/d)	Infiltration & ventilation stack:wind (ach)	Total (ach)
8-Mar-95	22.7	22.1	31.4	10.8	7.7	47.2	30.9	1.3	87.1	6.8	0.08	0.31
9-Mar-95	22.7	16.7	33.6	0.0	7.5	34.7	27.6	1.9	71.6	1.4	0.15	0.37
10-Mar-95	21.4	17.6	29.0	4.3	7.6	37.4	25.4	1.8	72.3	2.7	0.10	0.32
11-Mar-95	17.3	16.8	18.2	16.2	7.6	35.1	24.2	1.7	68.6	1.5	0.10	0.32
12-Mar-95	17.6	20.6	21.8	22.4	7.8	44.4	28.8	1.5	82.5	5.4	0.08	0.31
13-Mar-95	17.8	19.1	23.5	18.6	7.8	40.5	29.3	1.5	79.0	3.8	0.12	0.34
Average	19.9	18.8	26.3	12.1	7.7	39.9	27.7	1.6	76.9	3.6	0.10	0.33

6.3 Mechanical Systems

A condensing gas water heater provided both domestic hot water and space heat (the latter through a four zone fan-coil unit). Ventilation is provided by a dual-core, cross-flow heat recovery ventilator of 90 L/s capacity.

6.3.1 Domestic Water Heating

Hot water demand for the unoccupied house averaged only 16 L/day (Table 6.5) - much less than would be typical[13] for an occupied condition.

The solar domestic water heating system was operational only from May, 1995 on, due to problems with its pump. Preheat tank temperatures from May to August, 1995 were typically in the 60C to 70C range due to the very small hot water demand.

6.3.2 Heat Recovery Ventilation

Ventilation air flow averaged 30 L/s over the winter period from October, 1994 to April, 1995 (turned down to about 20 L/s for most of the winter due to being unoccupied). The design flow for the house was 47 L/s (F326 flow was 70 L/s). With the unit operating at design flow rates of about 50 L/s (March and April, 1995), it averaged 9% out of balance. Under these conditions, the unit specific power use was 2.1 W/L/s.

The sensible HRV efficiency averaged 75% for the winter period - consistent with its rated efficiency of 85% at 0 C (outside temperatures over the period averaged 6.9 C), and the 9% flow imbalance.

The sensible system efficiency (HRV plus ducts) averaged 69% - a drop of 6% due to the 2.5 m long insulated ducts.

6.3.3 Space Conditioning

The four-zone air distribution system was tested for air flows (Appendix C). Under normal operation, the damper to each zone was set to the minimum opening (~30%). However, due to a malfunctioning control damper, the main zone (living/dining/entry) received full flow for all the tests.

With dampers to the main and family room open, the main (living room) zone received a total of 98 L/s, the family/media room 74 L/s, bedrooms a total of 56 L/s and the office 36 L/s, for a total of 263 L/s.

With dampers to the main and bedroom zones open, the flow to the main zone dropped to 82 L/s, while the flow to the bedrooms increased 45% to 81 L/s. Air flow to the office stayed about the same, while flow to the family room dropped to 39 L/s.

Circulation fan energy use was about 120 VA (50 W, pf 0.4), with a flow of about 263 L/s and a static pressure of 66 Pa.

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[13] Seven R-2000 houses averaged 256 L/day (71 L/person/day) [3]

Table 6.5

B.C. Advanced House

MECHANICAL SYSTEMS:

		1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr	YEAR	Remarks
DHW demand: Maximum	(L/d)	434	150	22	554	27	84	610	40	0	39	222	8	554	610	610	daily maximum
Average daily	(L/d)	17.1	6.1	1.2	38.7	2.6	27.9	31.2	1.6	0.0	4.9	64.2	0.3	13	19	16	
Mains temperature**: Avg.	(C)	11.1	14.5	18.0	9.4	19.7	7.2	10.0	11.1		6.4	7.2	9.5	10.9	7.9	8.9	flow weighted average
Minimum daily	(C)	11.0	13.7	18.0	16.5	17.6	17.2	8.8	10.7		6.4	6.8	9.5	18.0	6.4	6.4	summer max.; winter min.
Hot water temperature	(C)	44.9	59.6	45.4	25.3	27.6	17.7	42.6	39.3		42.5	41.9	44.2	34.0	36.9	35.9	off Aug - Oct
Water heating demand	(kWh/d)	0.7	0.3	0.0	1.3	0.0	0.8	1.2	0.1	0.0	0.2	2.7	0.0	0.5	0.7	0.6	Demand only
Heating efficiency	(%)						53%	68%	73%		89%	90%	90%		77%	77%	Space and DHW efficiency
DHW completeness		*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	*based on flow & energy*
SPACE HEATING:																	
Heating Energy output	(kWh/d)	8.3	8.9	7.4	8.6	5.2	9.6	23.4	27.1	38.8	29.0	15.8	9.1	7.7	21.8	15.9	incl. fans, pumps, tank loss
Heating Efficiency	(%)	*(solar DHW contributing to space heat)*					53%	68%	73%	91%	89%	90%	90%		80%		efficiency of gwt incl. pumps
Cooling Energy output	(kWh/d)	0	68	73	77	2	0	0	0	0	0	0	0	44.0	0.0	18.3	
Space condition complete.		*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	
HRV:																	
Input energy	(kWh/d)	3.2	3.2	2.8	3.1	1.4	1.4	1.4	1.4	1.8	1.4	2.9	3.3	2.8	1.9	2.3	no defrost energy
Specific power	(W/L/s)	2.1	2.1	1.8	2.0	2.2	2.1	2.3	2.3	2.9	2.4	2.1	2.1	2.1	2.3	2.2	
HRV completeness		*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	
Sensible HRV efficiency	(%)	75%	73%	74%	75%	70%	77%	73%	73%	74%	73%	79%	80%	73%	75%	75%	
Sensible System efficiency	(%)	72%	70%	71%	73%	62%	69%	66%	66%	66%	66%	74%	77%	70%	69%	69%	
Total HRV efficiency	(%)	25%	17%	17%	20%	22%	34%	34%	35%	37%	34%	33%	29%	20%	34%	28%	
Total System efficiency	(%)	24%	16%	16%	19%	19%	30%	30%	31%	33%	30%	31%	27%	19%	30%	25%	
Supply flow	(L/s)	**54.3**	**51.4**	**50.9**	**50.3**	*20.9*	*21.1*	*20.1*	*19.7*	*20.0*	*20.8*	**49.9**	**56.8**	45.6	29.8	36.3	Flows ~20 L/s are approx.
	(ac/h)	0.23	0.22	0.22	0.21	0.09	0.09	0.09	0.08	0.09	0.09	0.21	0.24	0.19	0.13	0.16	(limit for 20 cm flow collar)
Exhaust flow	(L/s)	**49.9**	**50.2**	**50.0**	**49.7**	*25.2*	*24.3*	*24.4*	*23.9*	*24.0*	*25.2*	**45.2**	**51.5**	45.0	31.2	36.9	
	(ac/h)	0.21	0.21	0.21	0.21	0.11	0.10	0.10	0.10	0.10	0.11	0.19	0.22	0.19	0.13	0.16	
Flow Imbalance*	(%)	8%	2%	2%	1%	-20%	-15%	-22%	-21%	-20%	-21%	9%	9%	-1%	-11%	-7%	
Supply core out	(C)	23.5	23.2	25.1	22.7	24.9	25.0	19.4	19.4	19.5	21.2	19.8	20.5	23.9	20.7	22.0	
Supply core dT	(C)	7.7	5.6	6.0	6.4	8.0	11.3	13.7	14.2	14.9	13.0	11.9	9.9	6.7	12.7	10.2	
Exhaust core in	(C)	23.6	22.6	24.6	22.2	24.0	24.2	18.7	18.8	19.0	20.7	20.3	20.8	23.4	20.4	21.6	
Exhaust core dT	(C)	4.9	3.1	3.3	3.6	3.7	5.8	7.0	7.3	7.8	6.7	7.1	5.6	3.7	6.7	5.5	
Exhaust RH at inlet	(%)	45%	55%	55%	61%	56%	40%	44%	41%	39%	45%	39%	41%	54%	41%	47%	

**HRV flow imbalance = 100 x (supply flow - exhaust flow)/supply flow (%)*

Under normal operation, the zone damper would open fully for any of the following reasons:

- heat called for by zone thermostat,
- occupant enters the zone (detected by passive infra-red/motion sensor)[14], and/or
- system is in cooling mode.

In addition, the bedroom zone damper was fully opened during normal sleeping hours (programmable).

In March, 1995, occupancy was simulated by controlling the dampers to simulate occupants entering and leaving various zones - forcing zone dampers to open and close accordingly. In addition, radiant heating and zone air thermostats were regulated according to a pre-defined pattern (see section 6.2.6 and Appendix A.4.

When the solar DHW system was brought on line in May, 1995 we noticed that, for several hours following domestic water demands, the space heating supply loop temperatures increased to values approaching the solar DHW preheat tank (~70C in some cases) - much higher than the set-point for the gas water heater. The result was that some of the space heating was being provided by the solar system - inflating the apparent efficency of the gas water heater. Since the house was unoccupied, hot water demand was very low and the solar system was essentially stalled - resulting in very high solar preheat tank temperatures.

Winter heating system efficiency averaged 80% (space and water heating)[15] for the period from October, 1994 to April, 1995. This is significantly less than the 91% efficiency from CANMET tests on a similar heating system[16]. Note however, that the efficiency from January to April averaged about 90% (Table 6.5).

6.4 Power and Energy Use

6.4.1 Peak Power

Peak electrical power use was 3.5 kW and peak natural gas use was 7.1 kW - both in November, 1994 (Table 6.6), however these are probably not representative of occupied conditions. Note that the peak values shown are for a full hour (the water heater has a rated input of 31 kW - so a peak of 7.1 kW means it was on only about 23% of the hour).

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[14] zone damper closes to minimum setting if no occupants are detected for a period of 10 minutes.

[15] Efficiency determined from total of domestic water heating, space heating demands (determined from flow times temperature change), and electrical energy to the space (controls, pumps, etc.), divided by the sum of gas energy fuel equivalent plus electrical energy to water heater and pumps. While the domestic water heating demands should be reasonably accurate (although very small, due to lack of occupants), the space heating demand is much less so due to a relatively small temperature drop across the space heating coil (typically about 0.7C). Since the sensors are only accurate to 0.1C, the potential error is quite high. The circulation pump was sized to be able to handle all four zones, however typically only one zone called for heat at a time.

[16] *"Performance Testing of Integrated Space/Water Heating System in the INNOVA Advanced House - Ottawa"*, by A. Hayden et al. Note that the efficiency they quote includes electrical energy for igniter, controls and induction fan.[5]

6.4.2 Energy Use Breakdown and Comparisons

Total electrical supply for the year amounted to 6,241 kWh - broken down as follows:

- space heating loop pumps, and the continuously operating furnace and HRV fans consumed about 4.5 kWh/day, or 1,643 kWh per year,
- Excluding fans and pumps, inside electrical energy use averaged 9.7 kWh/day, or 3,543 kWh per year (this is much less than is typical for an occupied house[17], although only slightly less than the Advanced house total electrical budget of 3,838 kWh per year), including -
  - about 2.4 kWh/day (877 kWh/year) for the monitoring system,
  - refrigerator used 465 kWh per year,
  - inside lights used 643 kWh over the year - considerably more than the 412 kWh budgetted (some of this difference could be due to the use of lighting for security purposes in the unoccupied house),
- outside electrical energy use averaged 2.9 kWh/day, or 1,072 kWh per year - considerably more than the 183 kWh per year budgetted (outside lights were kept on as a security precaution in the unoccupied house).

DAS monitored **water heating demand**[18] averaged only about 0.6 kWh/month - amounting to an annual total of approximately 224 kWh (energy supply ~280 kWh). This is not typical of occupied conditions. The solar water heating system was operational only from May, 1995.

Over the year, gas energy supply amounted to 6,025 kWh (manual meter), or **21.7 GJ** for space heat and minimal water heating. A HOT-2000 (ver. 6.02) run predicted 4,165 kWh (Figure 4.1), or 15.0 GJ, for space heat only, using long-term Vancouver weather under occupied conditions. HOT-2000 also predicted 5,470 kWh or 19.7 GJ for space heat using long-term weather under unoccupied conditions.

HOT-2000 predicted 20.9 GJ of useful solar contribution for the unoccupied run. The calculated solar contribution (losses minus gains) from the monitored results averaged 15.5 kWh/day or 20.4 GJ per year (Table 6.6).

Using the manual meters, total annual energy consumed amounted to 12,266 kWh or 45.4 kWh per square metre of floor area. This is well below the budgeted total energy use of 14,167 kWh for an **occupied house** under average weather conditions (Figure 4.1).

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.

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[17] Seven R-2000 houses used 25.7 kWh/day [3] .

[18] Water heating demands were determined from water flow times temperature difference

Table 6.6

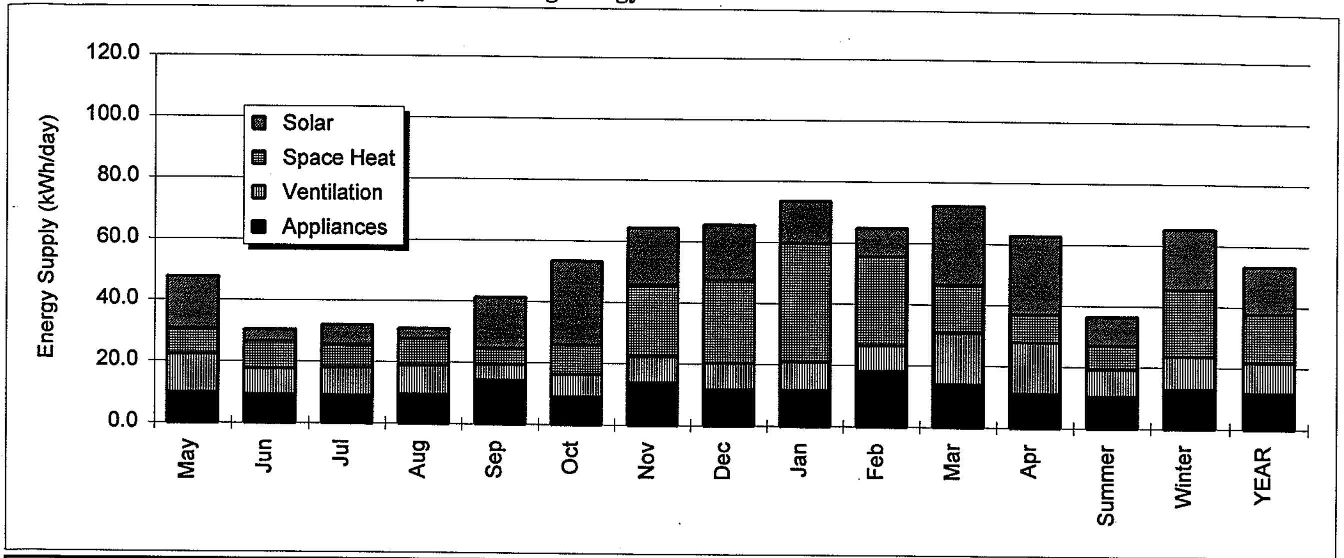
B.C. Advanced House

ENERGY & POWER:

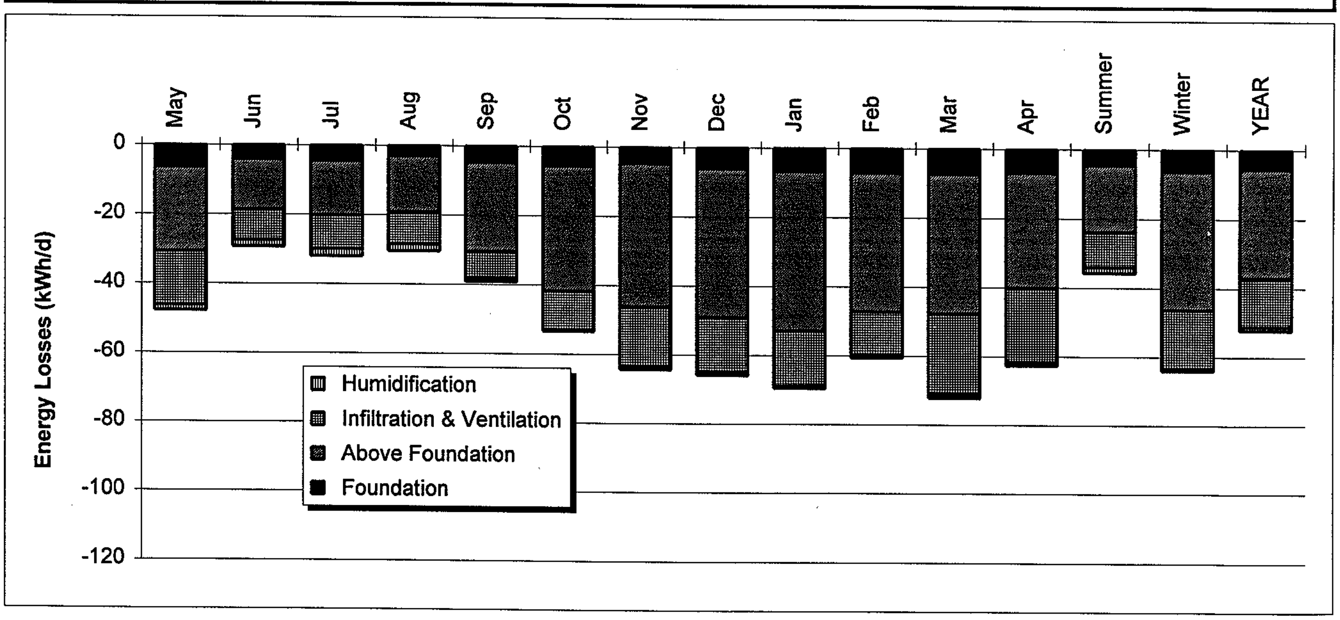
		1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr	YEAR	Remarks
SUPPLIES: HRV + pumps	(kWh/d)	4.9	4.9	4.8	4.8	4.0	6.2	5.1	4.9	4.4	4.3	5.1	4.9	4.7	5.0	4.9	
Base electric	(kWh/d)	5.5	4.7	4.8	4.9	10.2	4.8	9.0	7.0	6.9	13.5	9.2	6.6	6.0	8.1	7.3	
Solar supply	(kWh/d)																
Space + DHW supply	(kWh/d)	9.0	9.3	8.2	9.3	0.0	14.7	31.7	33.2	36.2	30.3	19.5	10.2	7.2	25.1	17.6	integrated space & DHW
Monitoring	(kWh/d)	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	
Outside	(kWh/d)	0.4	1.5	1.7	3.0	4.4	5.1	5.0	1.3	1.5	4.7	3.6	1.8	2.2	3.3	2.8	
TOTAL	(kWh/d)	22.3	22.8	21.9	24.5	21.0	33.2	52.4	48.8	51.4	55.3	39.9	26.0	22.5	43.8	34.9	incl. 2.4 kWh/d monitoring
Energy Completeness		*91%*	*100%*	*55%*	*76%*	*78%*	*6%*	*98%*	*100%*	*60%*	*24%*	*98%*	*99%*	*80%*	*69%*	*74%*	*All energy supplies*
HOURLY PEAKS:																	
DHW & Space supply	(kW)	0.8	2.8	0.8	1.9	0.0	1.4	7.1	3.0	3.1	2.3	3.6	0.8	2.8	7.1	7.1	max. (natural gas)
Total gas supply	(kW)	0.8	2.8	0.8	1.9	0.0	1.4	7.1	3.0	3.1	2.3	3.6	0.8	2.8	7.1	7.1	max. (natural gas)
Total electrical supply	(kW)	1.9	0.7	0.8	1.8	3.2	1.5	3.5	2.8	2.5	1.9	3.0	2.7	3.2	3.5	3.5	max. (electricity)
SPACE HEATING:																	
Delivered energy:**																	
Appliances	(kWh/d)	9.8	9.2	9.0	9.5	14.2	9.0	13.8	11.7	11.6	18.1	14.0	11.1	10.4	12.8	11.8	
Ventilation	(kWh/d)	12.5	8.6	9.1	9.5	5.2	7.4	8.6	8.8	9.3	8.4	16.8	16.9	9.0	10.9	10.1	
Space Heat	(kWh/d)	8.3	8.9	7.4	8.6	5.2	9.6	23.4	27.1	38.8	29.0	15.8	9.1	7.7	21.8	15.9	
Solar	(kWh/d)	17.0	3.9	6.5	3.5	16.7	27.5	18.6	18.0	13.9	9.3	25.7	25.6	9.5	19.8	15.5	
Calculated Losses:																	
Foundation	(kWh/d)	6.4	4.1	4.4	2.9	4.8	5.6	4.6	6.0	6.8	7.0	7.4	6.9	4.5	6.3	5.6	
Above Foundation	(kWh/d)	24.3	14.5	15.8	16.2	25.5	36.1	41.5	43.0	46.1	40.1	40.3	33.3	19.3	40.1	31.4	
Infiltration & Ventilation	(kWh/d)	15.4	8.8	9.6	9.2	8.0	11.2	17.4	16.1	16.1	12.7	23.5	21.4	10.2	16.9	14.1	
Humidification	(kWh/d)	1.7	1.9	2.3	2.0	0.9	0.5	0.9	0.8	0.7	0.8	1.1	1.2	1.8	0.9	1.2	
TOTAL	(kWh/d)	47.8	29.3	32.0	30.4	39.3	53.5	64.4	66.0	69.6	60.7	72.3	62.8	35.8	64.2	52.3	
Buffering (crawlspace & garage)	(kWh/d)	-1.0	-1.0	-1.1	2.1	2.3	4.8	8.9	6.8	6.5	3.9	4.1	2.2	0.3	5.3	3.2	

***Sum of supplies may not equal sum of losses due to being based on different number of days (if data incomplete). Also occupant heat gains not shown.*

Figure 6.8 B.C. Advanced House Space heating energy balance



Delivered energy*	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	May-Sep Summer	Oct-Apr Winter	YEAR
Appliances	9.8	9.2	9.0	9.5	14.2	9.0	13.8	11.7	11.6	18.1	14.0	11.1	10.4	12.8	11.8
Ventilation	12.5	8.6	9.1	9.5	5.2	7.4	8.6	8.8	9.3	8.4	16.8	16.9	9.0	10.9	10.1
Space Heat	8.3	8.9	7.4	8.6	5.2	9.6	23.4	27.1	38.8	29.0	15.8	9.1	7.7	21.8	15.9
Solar	17.0	3.9	6.5	3.5	16.7	27.5	18.6	18.0	13.9	9.3	25.7	25.6	9.5	19.8	15.5
Calculated Losses:								kWh/day							
Foundation	6.4	4.1	4.4	2.9	4.8	5.6	4.6	6.0	6.8	7.0	7.4	6.9	4.5	6.3	5.6
Above Foundation	24.3	14.5	15.8	16.2	25.5	36.1	41.5	43.0	46.1	40.1	40.3	33.3	19.3	40.1	31.4
Infiltration & Ventilation	15.4	8.8	9.6	9.2	8.0	11.2	17.4	16.1	16.1	12.7	23.5	21.4	10.2	16.9	14.1
Humidification	1.7	1.9	2.3	2.0	0.9	0.5	0.9	0.8	0.7	0.8	1.1	1.2	1.8	0.9	1.2
TOTAL	47.8	29.3	32.0	30.4	39.3	53.5	64.4	66.0	69.6	60.7	72.3	62.8	35.8	64.2	52.3
Buffering (crawlspace + garage)	-1.0	-1.0	-1.1	2.1	2.3	4.8	8.9	6.8	6.5	3.9	4.1	2.2	0.3	5.3	3.2



* *Sum of supplies may not equal sum of losses due to being based on different number of days (if data incomplete). Also occupant heat gains not shown*

Figure 6.8 shows a monthly energy balance of space heating supplies (based primarily on values derived from measurements) and space heating losses (calculated from building characteristics and actual temperatures. Solar energy supplied is calculated from the difference of daily losses and supplies. Buffering due to the crawlspace and garage is an indication of the amount losses would increase in the absence of these tempered spaces.

7 ENVIRONMENTAL

7.1 Water Management

Total water use averaged 41 L/day, of which 4.4 L/day was used outdoors. This is not likely to be typical of occupied use.

7.2 Waste Management

Total amount of waste generated was not monitored, although every attempt was made to reduce site generated waste. Using manufactured components for the building envelope, manufactured in climate controlled environments, reduced the normal amount of site generated framing waste.

Recycled materials used in the house included:

- Plastic wood used for an exterior deck. The locally manufactured product used post consumer plastics as the raw material.
- Rubber patio pavers are manufactured from automobile tires.
- Glass tiles, locally manufactured, are made from recycled glass.
- Site drainage material uses a mix of drain rock and recycled green glass.
- The raw materials for the roof tiles are waste products from other industrial processes - wood fibres from the pulp and paper industry, cement a by-product of the fertiliser industry.
- Loose fill cellulose insulation used in the main floor is a post consumer paper product.
- The drywall used in the house contains recycled gypsum.

7.3 Ozone Depletion Potential

- The only CFC use in the house was that contained within the refrigerator, as there was no readily available alternative.
- Convential construction practices use very few products that ozone depletion potential.
- It was decided that as the foam is totally encapsulated, and provides enhanced insulation values, by reducing energy demands the house will provide a beneficial environmental impact.
- The expanded polystyrenc foam used in the main floor walls uses a stcam expansion agent, thus not contributing to ozone depletion.

8 TECHNOLOGY ASSESSMENT

8.1 General Observations

The project was well received over all. However, there was two major concerns: financial, and clarity of purpose.

The major financial problem was simply put, there were not enough funds to support a major project of this scale. many potential participants were not fully briefed or convinced to participate, especially within the generally tight time frame for this type of project.

Clarity of purpose. Some saw this as a full scale research and development project, others saw it was a purely marketing effort, which the building industry in general is very good at. However, standard building industry marketing is focused purely on aesthetic design considerations and siting. Technical issues are usually a very minor part in the mind of both the professional builder and the consumer.

The Advanced Houses program encouraged taking advantage of innovative products and systems as well as prototypes. This led to a confusion about what was being tested and showcased. Was it a purely an idea showcase, or was it market development for new ideas? This also makes it difficult for monitoring, especially when there is an overlap of products.

As research vehicle, totally "off the wall" ideas should be encouraged and tested and be proven that they don't work. This would, of course, be considered a failure from a marketing perspective.

On the other hand, as a demonstration of new leading edge technologies, such failures would not be encouraged, thus restricting the potential exposure and testing of new products.

The Advanced houses generated considerable interest from a relatively small market sector, and some professional trades. However, there were too many features, so that a coherent presentation was difficult to make. On one hand, the importance of stressing "the house as a system" was made, but on the other there were so many products and features that to make a comprehensible explanation to the public it was necessary to stress that the project was a "catalogue" of new products and technologies, which seemingly indermines the basic systems concept.

In setting out this kind of program, it would probably be more beneficial to remove the competitive nature of the project once basic concepts have been accepted, and ensure there is adequate time and funding in place to carry out the project completely.

The public, once appraised of the potential of new materials and systems, immediately wants to know availability and price. This is great for those products that are market ready and in commercial production. For those that are not there yet, the exposure could in fact be counterproductive.

Most of the public could not grasp the concept of the project. They understood that a large sum of moneys was expended, and equated the cost and value of the house with the total construction costs (i.e. administration, marketing, prototype testing, design and monitoring, etc). This confusion only helped to convince many that the new technologies being presented may be nice, but not affordable by the average person.

8.2 Market Potential of Selected Technologies

Further development of some of the prototype products is needed, in particular home automation products and systems. There is a great ambivalence about the value of such systems in the public mind, and concern about systems reliability and function in unstable power areas (e.g. what happens in a power outage?)[19]. Further development is needed, and greater public awareness to promote the functions provided rather than the means. In other words, rather than stress home automation, stress the benefits of the services provided by new hardware controls strategies.

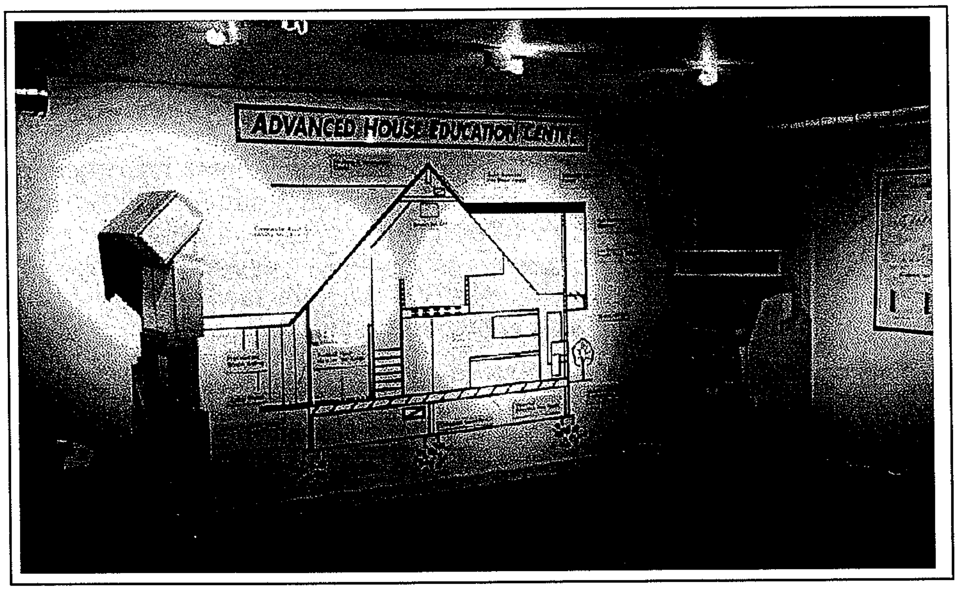
Landscape components (plastic wood, rubber paving blocs) are market ready, with a good public reception.

There was an excellent public response for the recycled, environmentally friendly products: roof tiles, glass tiles, prefinished wood products, plastic wood, and rubber paving blocks.

8.3 Impact of Advanced House on Building Industry/Consumers

The garage was finished as a display centre and meeting room during the year the house was open to the public for display (Figure 8.1).

Figure 8.1 Display



[19] In the case of the B.C. Advanced house, a conventional thermostat in the living room was available as a backup in the event of failure of the CEBUS controls. In the event of a power failure, however, the fans would not operate, so no heat would be delivered.

The house received wide public exposure both within the Greater Vancouver area and across the country as well as in the USA, Japan and Europe. Well over 20,000 people visited the house during the year it was open. Overall, the house generated considerable exposure to the new products and technologies available to the housing market.

Original plans were to prepare a consumer survey to randomly do an "exit poll" to garner public feedback. Unfortunately, it was not possible to carry through with this plan. However, numerous comments were received on the information request form that was available to visitors. Overall, there was a very positive feeling to the house. There were only a handful of negative comments to the entire project.

Many visitors went to the house because they were in various stages of planning for a new home or renovation, and were interested in specific product information.

The roof (a slate look-alike but made from recycled materials) was a hit. Many requests for supplier name were received, not only locally but from across North America. Had a manufacturer been ready with the product, they would have received a head start on marketing.

The mechanical system was a feature at the house. This is also a system that few people pay attention to in the normal course, so looking at equipment judged it too complex, and expressed concerns about ongoing maintenance, although most were satisfied when it was explained to them.

Some products and systems in the house are already entering the mainstream housing market. Perhaps not all may be in the mass market speculative construction sector, but in the custom home market. These include higher performance windows, water saving low flush toilets, vented toilets, and recycled content building materials. The intergrated mechanical system approach is being used more often.

Despite high interest levels, a number of suppliers are no longer in business. Their business failures, however, in most cases are a factor of low capitalisation and inadequate preparation or market development. Companies no longer producing product or operating under alternative corporate structures include: Whitewall Systems (prefab wall system), Innovative Waste Technologies (production of recycled rubber tire pavers), Envirosafe 2000 (manufacturers of environmentally responsible, low emissions cabinets), and Signature Wood Flooring (prefinished wood flooring).

The industry will gain many benefits if the information gained from the construction and marketing of the Advanced Houses is collected and made available for future ventures. The value will be not only in asserting the positive benefits, but also a review of those elements that did not work, and why they did not perform as expected. This applies equally to the technical issues as to the administrative and marketing aspect of the projects.

9 CONCLUSIONS and RECOMMENDATIONS

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

- the use of low emission materials to create a healthy indoor air environment,
- the use of components using recycled materials reduced the impact of the house on the environment,
- the use of low-flow faucets, and low water use appliances to make it possible to reduce overall and hot water usage,
- an energy efficient envelope to significantly reduce space heating energy use, and
- an energy efficient space and water heating system,
- zoned ventilation system to optimize system effectiveness, and
- integration of new technologies and products within a conventional building design.

Some design aspects were not as succesful:

- the code requirement for time-operated pumping through the space heating loop (to avoid stagnant water mixing with potable water) contributed to excessive energy use and overheating,
- the lack of an easily implemented, purely ventilation mode of operation (without heat recovery), contributed to overheating.. Note that this is a common fault in HRV equipped houses,
- the lack of a fully implemented space cooling control contributed to overheating,
- automatic faucet - technology not fully developed,
- not all aspects of the CEBUS home automation system were successfully implemented, as this was the first application of a new protocol, combined with a lack of adequate resources, and
- administration and communication processes that failed to keep up with all activities, so that adequate communication with all trades and suppliers and product evaluation for all products could not be carried out.

The integrated space and water heating system operated with an average natural gas to delivered heat conversion efficiency of 80%.

The double core, cross-flow heat recovery ventilator operated with a sensible core efficiency of 75%. The HRV used an average of 79W, while delivering approximately 30 L/s air flow.

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), and including about 2.4 Wh 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 - considerably over the budgetted 0.5 kWh per day.

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 equivalent energy of 6,025 kWh per year.

The total energy usage amounted to approximately 12,266 kWh, or 45.4 kWh per square metre of heated floor area. This energy consumption is less than the budgetted energy use of 14,167 kWh per year for an **occupied house.**

10 REFERENCES

1. *"Advanced Houses Program Technical Requirements"*, by R. Dumont, SRC for CANMET NRCan. June, 1992

2. *"Indoor Air Quality Monitoring Results - Advanced Houses"*, by Peter Piersol, ORTECH Corporation for the Saskatchewan Research Council and NRCan. 18 July, 1994: Lab reports

3. *"R-2000 Monitoring Program Data Processing Results"* by K. Cooper of SAR engineering ltd. for CANMET, NRCan. 31 March, 1995

4. Status and processed data reports by K. Cooper of SAR engineering ltd. (January, 1994 to August, 1995) for CANMET NRCan.

5. *"Performance Testing of Integrated Space/Water Heating System in the INNOVA Advanced House - Ottawa"*, by A. Hayden et al., for NRCan

6. *"Healthy Housing Project Final Report"* by K. Cooper of SAR engineering ltd. for CMHC, 31 August, 1995

7. *"Indoor Air Quality and Ventilation Rates in R-2000 Houses"* by T. Hamlin and J. Gusdorf for CANMET, NRCan, February, 1996

APPENDIX A: Monitoring Plan

The following are included:

1. Monitoring plan
2. Sensor layout
3. Heating system
4. Simulated occupancy test conditions

Local Monitoring Coordinator: Ken Cooper
Telephone: 1 604 525-2239
Faxphone: 1 604 525-2146

B.C. ADVANCED HOUSE - Monitored Parameters

Analog Channels: 33
Counter Channels: 03
Digital Channels: 14

BUILDING ENVELOPE	COMPONENT	MONITORED PARAMETER	CoPilot CODES	MONITORING OBJECTIVE	TYPE OF ANALYSIS	MONITORING PROTOCOL	METHOD	SAVE RATE	TYPE OF SENSOR
Outside Conditions	Envelope	Horizontal radiation	SOLhor	Determine heat loss coefficient	Effect of solar gains on balance point	Locate sensor at roof peak in unobstructed area (over study)	DAS - A	Hourly	Pyranometer
		Outside temperature	Tout	Determine envelope heat loss	Wall, window, door and ventilation heat loss	Locate sensor on north-east side of house under eaves	DAS - A	Hourly	Shielded thermistor
		Outside RH and temperature	RHout	Determine HRV enthalpic efficiency	Enthalpic efficiency	Locate RH sensor in HRV supply air duct, close to outside wall	DAS - A	Hourly	RH sensor
			Trhout	Determine moisture added to inside		Locate temperature sensor next to RH sensor	DAS - A	Hourly	Thermistor
Inside Conditions	Second floor	Temperature - SE bedroom	T2bed	Determine envelope heat loss	Wall, window, door and ventilation heat loss	Locate sensor on wall, 1.2m from floor	DAS - A	Hourly	Shielded thermistor
		Temperature - N, bedroom/study	T2stdy		using weighted values based on heat loss	Locate sensor on wall, 1.2m from floor	DAS - A	Hourly	Shielded thermistor
	First floor	Temperature - N, family room	T1fam		associated with each temperature zone	Locate sensor on wall, 1.2m from floor	DAS - A	Hourly	Shielded thermistor
		Temperature - S, living room	T1liv		Bin and graph all temperatures for comparison	Locate sensor on wall, 1.2m from floor	DAS - A	Hourly	Shielded thermistor
		Temperature - S, master bedroom	T1mbed		with other advanced houses	Locate sensor on wall, 1.2m from floor	DAS - A	Hourly	Shielded thermistor
Adjoining Spaces	Unheated crawlspace	Temperature	Tcrawl	Determine envelope heat loss	Floor heat loss	Locate sensor mid-height in center of crawlspace	DAS - A	Hourly	Thermistor
	Garage		Tgar		Adjoining wall heat loss	Locate sensor mid-height on wall adjoining house	DAS - A	Hourly	Shielded thermistor
MECHANICAL SYSTEMS	**COMPONENT**	**MONITORED PARAMETER**	**CoPilot CODES**	**MONITORING OBJECTIVE**	**TYPE OF ANALYSIS**	**MONITORING PROTOCOL**	**METHOD**	**SAVE RATE**	**TYPE OF SENSOR**
Energy Supply to Space Heating and DHW Systems	Gas space/DHW tank	Tank ontime	OTgwt	Determine input energy	Integrated system efficiency	Locate sensor in line dedicated to hot water tank	DAS - D	Hourly	Voltage status sensor
		Natural gas consumption	NGgwt		Energy balance	Locate sensor in gas line dedicated to hot water tank	DAS - D	Hourly	Gas meter with pulse output
		Electric consumption	EEgwt		HOT2000 fan input	Determine using OTgwt and measured power draw	CoPilot	Hourly	None required
	Radiant floor pump		EEradp		Verify technical requirement	Connect sensor to detect on/off voltage signal from fan or pump	DAS - D	Hourly	Voltage status sensor
	Fan coil pump		EEshp			control. Measure power draw using a Watt meter	DAS - D	Hourly	Voltage status sensor
	Circulation fan		EEshf			Locate sensor in line dedicated to circulation fan	DAS - A	Hourly	Current transformer
	Solar DHW pump		na			Determine consumption based on hours of sunlight	Calculate	Daily	Not required
Energy Demand from Space Heating and DHW Systems	Radiant (5), duct (6) and DHW coils	Water flow from hot water tank	Vshc	Determine output energy	Integrated system efficiency	Locate sensor in supply line to, or return line from, exchanger	DAS - D	Hourly	Flow meter with pulse output
		Supply temperature from hot water tank	Tshs		Energy balance	Locate sensors as close to hot water tank as possible	DAS - A	Hourly	Thermistor probe
		Return temperature to hot water tank	Tshr				DAS - A	Hourly	Thermistor probe
	Domestic hot water	Water flow	Vdhw		Calculate DHW system COP	Locate sensor in cold water line to solar storage tank	DAS - C	Hourly	Flow meter with pulse output
		Temperature of cold service water	Tcw		Energy balance	Locate sensor at entry point of service water to house	DAS - A	Hourly	Thermistor probe
		Solar storage tank outlet temperature	Tsolot		Calculate DHW demand, HOT2000 DHW model	Locate sensor at outlet from solar storage tank	DAS - A	Hourly	Thermistor probe
		Temperature of hot water to house	Tdhw		Verify technical requirement	Locate sensor as close to solar storage tank as possible	DAS - A	Hourly	Thermistor probe
Cooling System	Cooling damper	Damper open/closed status	STcool	Determine fresh air supply for cooling	Energy balance	Locate sensor at damper door	DAS - D	Hourly	Microswitch
Ventilation System	Heat recovery ventilator (HRV)	Fan electric consumption	EEhrvf	Determine HRV efficiency	Sensible and enthalpic system efficiency inputs	Locate sensor in line dedicated to HRV	DAS - A	Hourly	Watt transducer
		Supply air flow to house	Fsup	Determine moisture added to inside air	for HOT2000 Program	Locate sensor in warm side supply duct	DAS - A	Hourly	Pitot array and transducer
		Exhaust air flow from house	Fexh	Evaluate indoor RH levels	Verify technical requirement	Locate sensor in warm side exhaust duct	DAS - A	Hourly	Pitot array and transducer
		Supply air temperature from core	Tsupou			Locate sensor at fresh air outlet from HRV	DAS - A	Hourly	Thermocouple grid
		Exhaust air temperature to core	Texhin			Locate sensor at exhaust air intake to HRV	DAS - A	Hourly	Thermocouple grid
		Exhaust air temperature at hood	Texhhd			Locate sensor as close to outside wall as possible	DAS - A	Hourly	Thermocouple grid
		Exhaust air RH	RHexh			Locate sensor in warm side exhaust duct	DAS - A	Hourly	RH sensor
		Thermocouple junction temperature	Tjcn	Determine thermocouple temperatures	None required	Locate sensor inside DAS near thermocouple channels	DAS - A	Not required	Thermistor
	Range hood	Fan electric consumption	EErgf	Determine input energy	Energy balance	Connect sensor to detect on/off voltage signal from fan control	DAS - D	Hourly	Voltage status sensor
					Verify technical requirement	Measure power draw using a Wattmeter			
		Exhaust temperature	Texhrg	Determine stove utilizability factor	Energy balance	Measure in center of range hood exhaust duct	DAS - A	Hourly	Thermistor

INSIDE ENVIRONMENT	COMPONENT	MONITORED PARAMETER	CoPilot CODES	MONITORING OBJECTIVE	TYPE OF ANALYSIS	MONITORING PROTOCOL	METHOD	SAVE RATE	TYPE OF SENSOR
Air Quality and Comfort	Ventilation system and source control measures	Carbon dioxide (CO2)	CO2bed	Verify acceptable exposure levels	Correlate with ventilation rates	Locate sensors in master bedroom	DAS - A	Short-term	CO2 sensor
			CO2fam	Determine system effectiveness	Document results	Locate sensors in family room	DAS - A	Short-term	CO2 sensor
		Other parameters as specified in the Advanced Houses Indoor Environment Monitoring Requirements	na	Determine source strengths		As specified in the Advanced Houses Indoor Environment Monitoring Requirements	Manual	Short-term	As specified in Indoor Environment Monitoring Requirements
UTILITIES	**COMPONENT**	**MONITORED PARAMETER**	**CoPilot CODES**	**MONITORING OBJECTIVE**	**TYPE OF ANALYSIS**	**MONITORING PROTOCOL**	**METHOD**	**SAVE RATE**	**TYPE OF SENSOR**
Electrical Service	Total house	Electric consumption	EEhse	Determine input energy	Energy balance	Locate sensor in electrical service line to panel	DAS - C	Hourly	kWh meter with pulse output
	Refrigerator		na		Verify technical requirements	Locate submeter in line dedicated to refrigerator	Manual*	Monthly	kWh meter
	Dishwasher		na		Validate HOT2000 defaults	Locate submeter in line dedicated to dishwasher	Manual*	Monthly	kWh meter
	Dishwasher heater		OTdish			Locate sensor to detect on/off signal from dishwasher heater	DAS - D	Hourly	Voltage status sensor
	Clothes washer		na			Locate submeter in line dedicated to clothes washer	Manual*	Monthly	kWh meter
	Clothes dryer		na			Locate submeter in line dedicated to dryer	Manual*	Monthly	kWh meter
		Dryer ontime	OTdryr	Determine utilizability factor	Energy balance	Locate sensor to detect on/off signal from clothes dryer	DAS - D	Hourly	Voltage status sensor
		Temperature - exhaust air	Tdryxh			Locate sensor in exhaust line from dryer	DAS - A	Hourly	Thermistor
	Power vacuum	Vacuum ontime status	OTvac	Determine ontime	Infiltration model	Connect sensor to detect on/off signal from vacuum control	DAS - D	Hourly	Voltage status sensor
	Inside lights	Electric consumption	na	Determine input energy	Verify technical requirement	Locate submeter in line dedicated to inside lights	Manual*	Monthly	kWh meter
	Outside circuits		EEout		Energy balance Validate HOT2000 default Verify technical requirement	Locate sensor in line dedicated to outside consumption	DAS - C	Hourly	kWh meter with pulse output
	Vehicle refueler	Compressor electric consumption	na		Document results	Locate sensor in line dedicated to vehicle refueler compressor	Manual*	Monthly	kWh meter
	Monitoring system	Electric consumption	na		Energy balance	Measure power draw using a Wattmeter	Manual	One-time	Wattmeter
Gas Service	Stove	Natural gas consumption	NGstve	Determine input energy	Energy balance	Locate submeter in gas line to oven	DAS - D	Hourly	Gas meter with pulse output
	Clothes dryer		NGdryr			Locate sensor in gas line to dryer	DAS - D	Hourly	Gas meter with pulse output
	Fireplace		NGfire			Locate sensor in gas line to fireplace	DAS - D	Hourly	Gas meter with pulse output
	Outside use		NGout			Locate sensor in gas line to outside (vehicle refueller and BBQ)	DAS - D	Hourly	Gas meter with pulse output
Water Service	Total house	Water consumption	na	Determine total water consumption	Verify technical requirement	This is house meter installed by local utility	Manual*	Monthly	Water meter
	Outside water		na	Determine outside water consumption		Locate submeter to measure total outside consumption	Manual*	Monthly	Water meter
MONITORING SYSTEM	**COMPONENT**	**MONITORED PARAMETER**	**CoPilot CODES**	**MONITORING OBJECTIVE**	**TYPE OF ANALYSIS**	**MONITORING PROTOCOL**	**METHOD**	**SAVE RATE**	**TYPE OF SENSOR**
Monitoring Hardware	Data acquisition unit (DAU)	Voltage constant for 321	VC321	Verify operation of DAU	None required	Install according to senor connection diagram in senor	DAS - A	Hourly	Resistor
		Resistance constant for 321 plus WDT	RC321				DAS - A	Hourly	Resistor
		Voltage constant for 161	VC161				DAS - A	Hourly	Resistor
		Resistance constant for 161	RC161				DAS - A	Hourly	Resistor

APPENDIX A.2 MONITORING - SENSOR LAYOUT

Figure A.1 Ground Floor

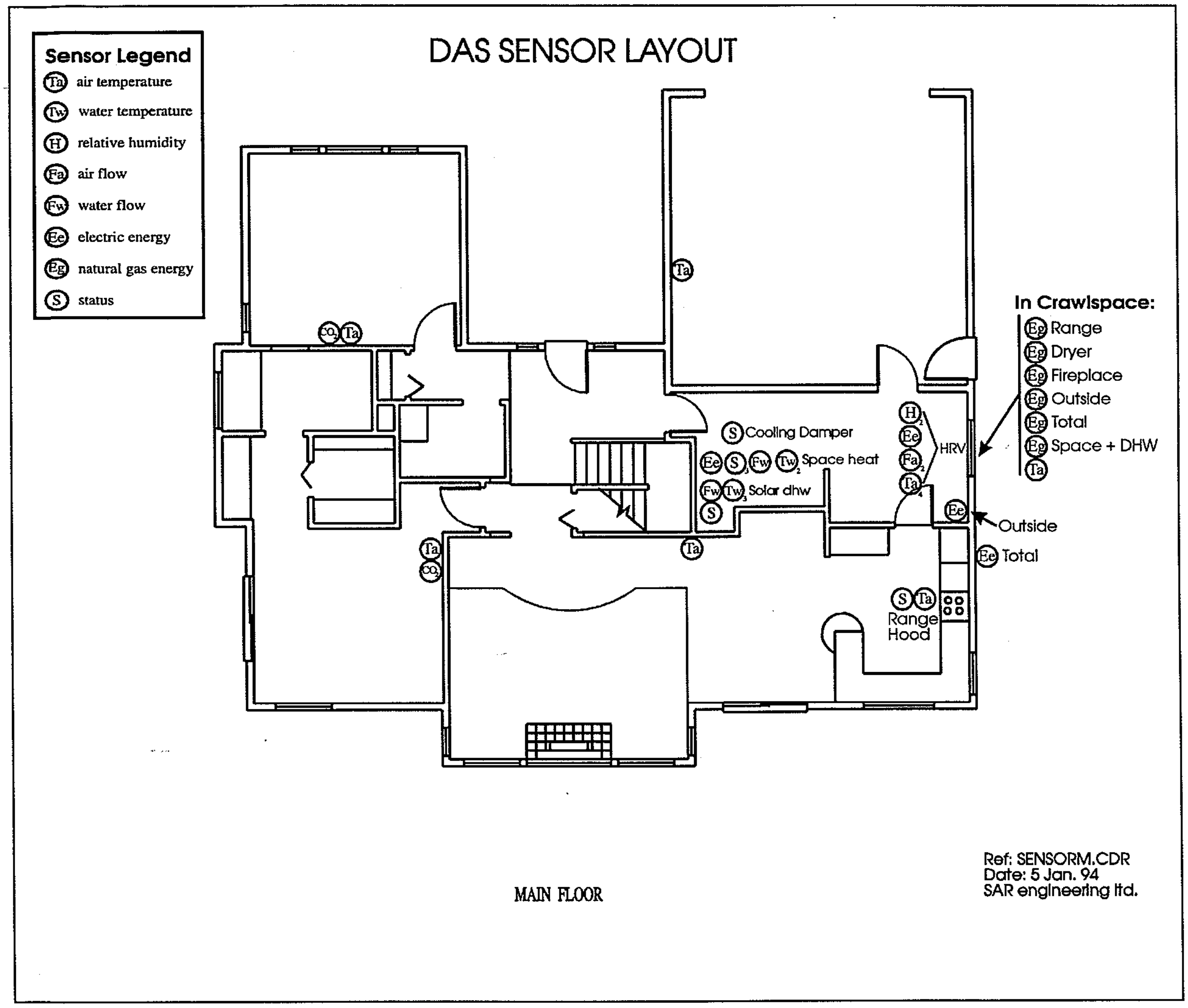
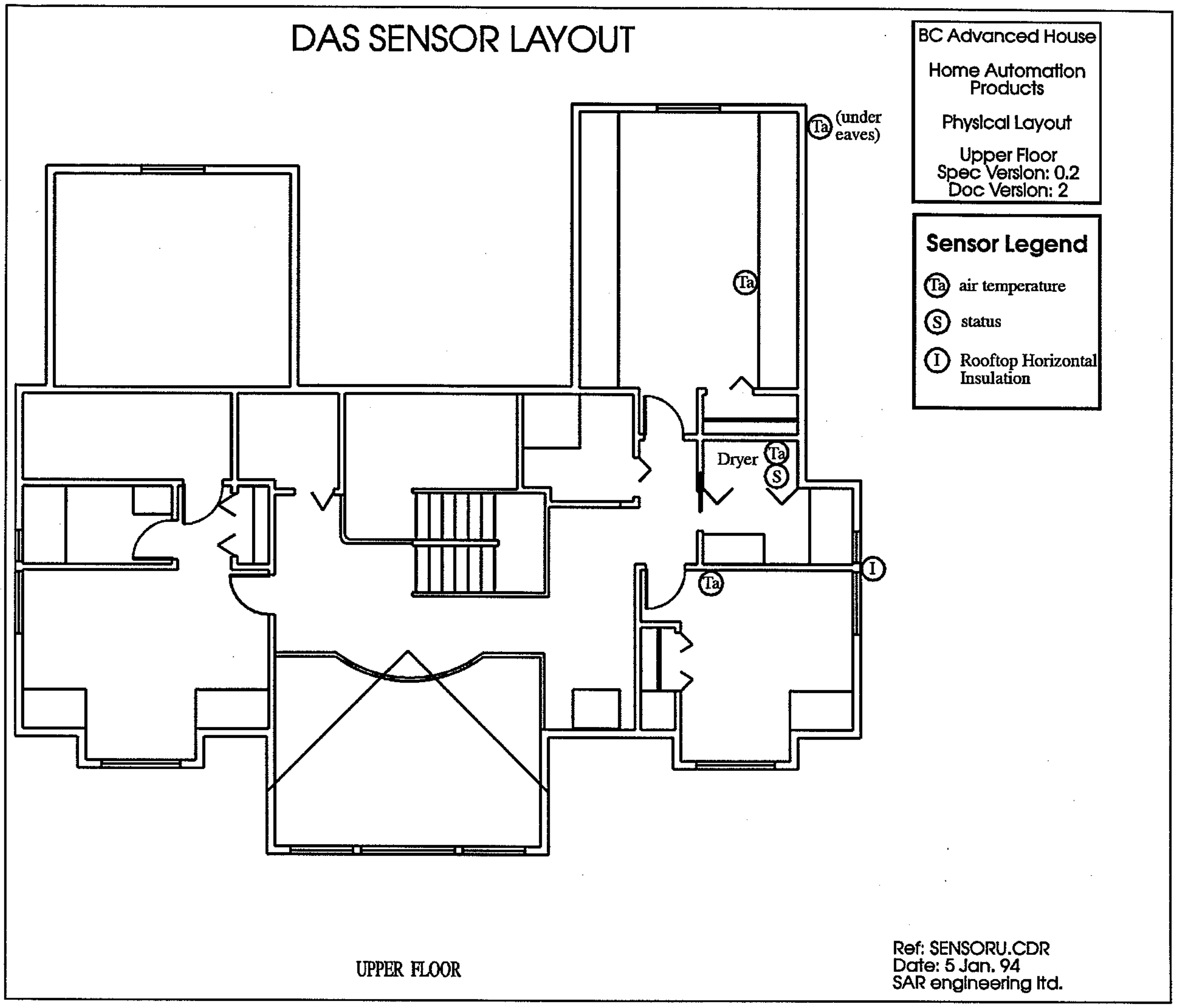


Figure A.2 Upper Floor



APPENDIX A.3: MONITORING - HEATING SYSTEM

Introduction

The heating system in the B.C. Advanced House demonstrates active solar domestic water heating and integrated natural gas domestic water and space heating.

System Description

Space and domestic water heating are supplied by an integrated system using a condensing gas water heater as the primary source of energy.

Domestic water is also pre-heated by a solar system and then brought up to demand temperature by the gas water heater. The solar system is a production model produced by Thermodynamics of Nova Scotia:

- 5.9 m^2 of collector area with a single-glazed cover,
- 22 watt photovoltaic panel coupled to a 24 volt DC pump
- drain-back operation of 50% glycol solution for freeze protection
- 182 L storage tank

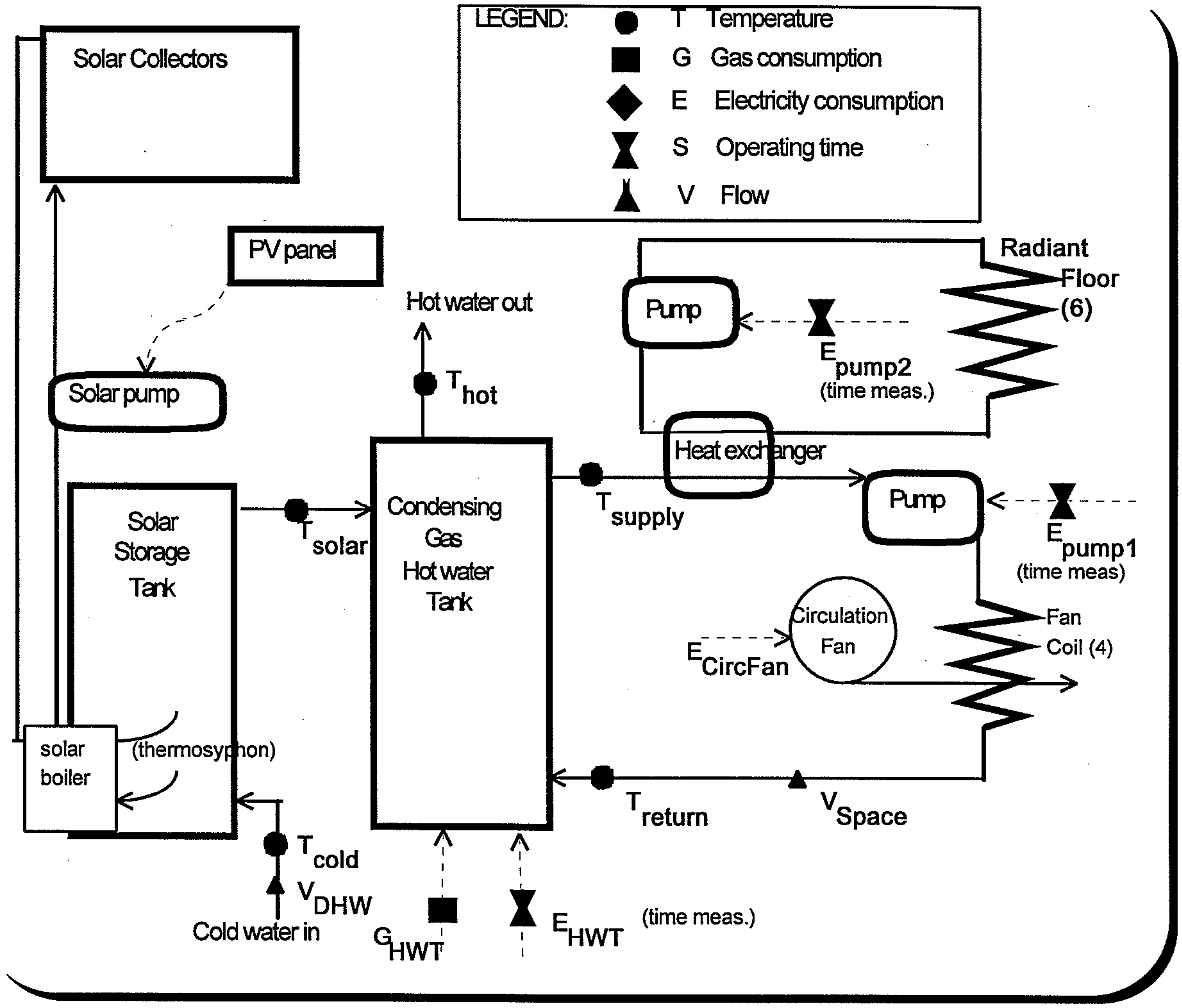
Hot water for heating the space is drawn from the gas water tank and circulated, directly to four coils in the forced air circulation system (four zones), and through a heat exchanger to six radiant floor zones (kitchen, bathrooms and utility room). The gas water tank is a production produced by Polaris:

- direct vent operation with combustion supply air drawn from outdoors
- 94% rated steady-state operation with condensation of moisture in the flue gases
- 29.3 kW (100,000 BTUH) rated input
- 189 L (41.7 Imp. gal.) integral storage tank

Monitoring Objectives

Space heat delivered	$Q_{SpaceHeat}$	MJ
Circulation pump energy	$Q_{SpacePumps}$	MJ
Circulation fan energy	$E_{CircFan}$	MJ
House hot water consumption	V_{DHW}	L (measured)
DHW load	$Q_{DHWload}$	MJ
Solar heat delivered to DHW	Q_{solar}	MJ
Storage tank stand-by loss	$Q_{Tankloss}$	MJ (measured during zero demand)
Net total load	$Q_{Netload}$	MJ
Back-up energy delivered	Q_{Backup}	MJ
Back-up system efficiency	$\eta_{Back-up}$	%

HEATING SYSTEM



Performance evaluation Equations:

Space heating load	$Q_{SpaceHeat} = V_{Space} \times 1 \times 4.19 \times (T_{Supply} - T_{Return}$	MJ
DHW load:	$Q_{DHWload} = V_{DHW} \times 1 \times 4.19 \times (T_{hot} - T_{cold}$	MJ
Solar heat delivered:	$Q_{solar} = V_{DHWload} \times 1 \times 4.19 \times (T_{solar} - T_{cold}$	MJ
Net total load	$Q_{Netload} = Q_{SpaceHeat} + Q_{DHWload} + Q_{Tankloss} - Q_{sola}$	MJ
Back-up energy delivered	$Q_{Backup} = G_{HWT} + E_{HWT} + E_{pump1} + E_{pump2}$	MJ
Back-up system efficiency	$\eta_{Backup} = 100 \times Q_{Netload}/Q_{Backup}$	%

NOTES:

Passive solar heating contribution is determined from a calculated energy balance

APPENDIX A.4: MONITORING - Simulated Occupancy

DHW:

Hot water load:	204	L/day (17 cycles at 12L each)
Utilities:		
Unoccupied base load:	18.2	kWh/day (approx. - includes monitoring system)
Added to base load:	4.4	kWh/day
Total	22.6	kWh/day (average during test)

SUBJECT: SIMUIATOR

(For weekends add 1 hour)

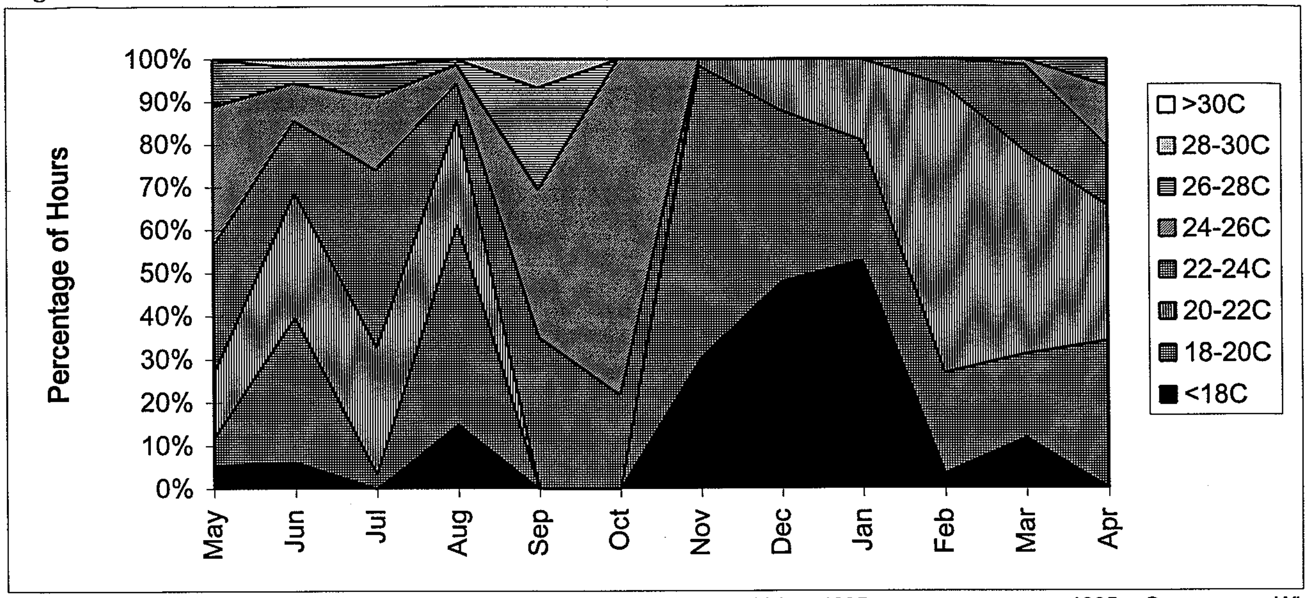
TIME	PRODUCT	ACTION	SETPOINTS Bedrooms	SETPOINTS LR/Media/Den	REMARKS
5:00 AM	HVAC	Radiant heaters on solid	18	off	Warms bathroom and kitchen floors (2 hours)
6:00 AM	HVAC	Heating normal	18	21	Daytime temperature settings
6:00 AM	HVAC	Bedroom damper normal	18	21	closed to minimum (occupancy sensor still active)
6:00 AM	HVAC	Great room damper open	18	21	Living room and dining areas at full air flow
7:00 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
7:00 AM	HVAC	Radiant heaters normal	18	21	Radiant returned to cycling (3 min on, 10 min off)
7:00 AM	LOAD	On	18	21	Simulated 837W 'base load' on - air flow at full
	HVAC	Media damper open	18	21	
7:15 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
7:30 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:00 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:15 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:30 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:45 AM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
9:00 AM	LOAD	Off	18	21	Simulated 837W 'base load' off - air flow min.
	HVAC	Media damper normal	18	21	
9:00 AM	HVAC	Office damper open	18	21	Air flow at full (9AM to 6PM); 120W 'base load' on
12:00 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
12:15 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
12:30 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
6:00 PM	LOAD	On	18	21	Simulated 837W 'base load' on - air flow at full
	HVAC	Media damper open	18	21	
6:00 PM	HVAC	Office damper closed	18	21	Flow at minimum; 100W 'base load' off
7:00 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
7:00 PM	LOAD	Off	18	21	Simulated base load off - flow remains at full
7:15 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
7:30 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
7:45 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:00 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:00 PM	LOAD	On	18	21	Simulated 837W 'base load' on - air flow at full
8:15 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
8:30 PM	DISHWASHER	Rinse/hold	18	21	Simulated hot water use (12 L)
9:00 PM	LOAD	Off	18	21	Simulated base load off - flow remains at full
10:00 PM	HVAC	Great room damper normal	18	21	Minimum flow
10:00 PM	HVAC	Media damper normal	18	21	Minimum flow
10:00 PM	HVAC	Bedroom damper open	18	21	Full flow
10:00 PM	HVAC	Heating setback	18	off	heating system off

APPENDIX B: Inside Conditions

Frequency histograms (graphs and tables) are shown in Figures B.1 to B.5 for:

1. Family room temperature,
2. SE bedroom temperature (second floor),
3. Study/Office temperature (second floor),
4. unheated crawlspace temperature, and
5. unheated garage temperature

Figure B.1 B.C. Advanced House: Family room temperature

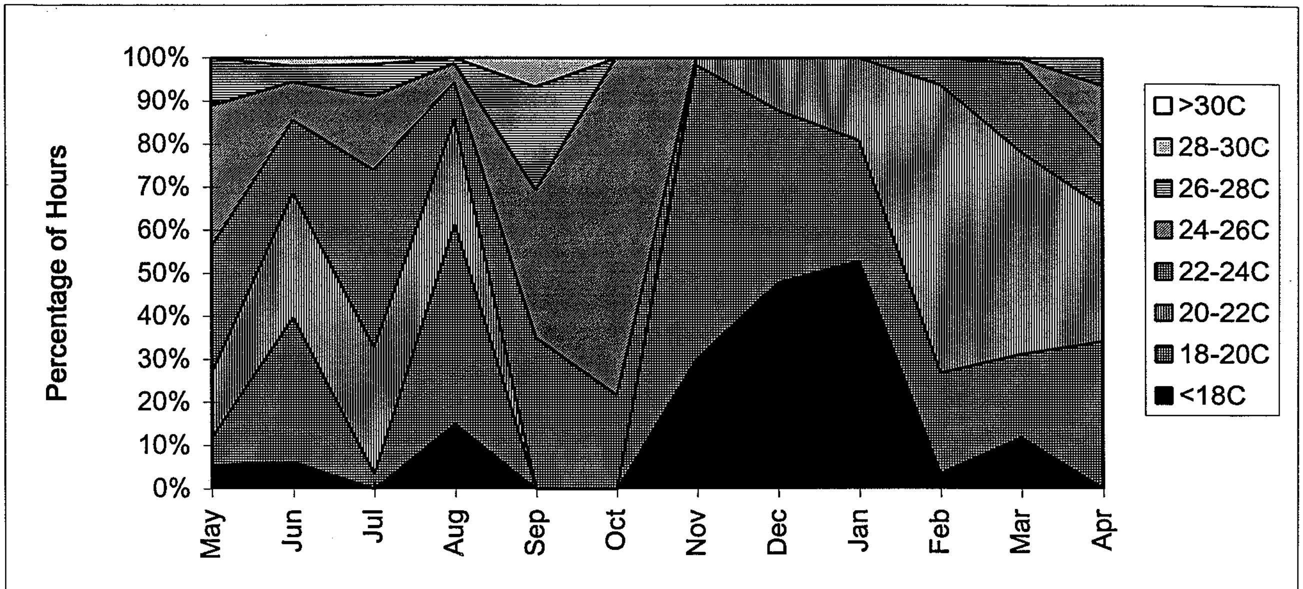


	1995			1995	1994			1994	1995			1995	Summer	Winter
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
Average	23.1	21.1	23.0	19.8	25.1	24.4	18.2	17.7	17.9	20.3	20.5	21.5	22.4	20.1
Minimum	15.1	17.1	19.4	15.7	22.1	23.3	15.9	14.3	14.5	17.6	15.6	17.9	15.1	14.3
Maximum	27.6	29.7	28.8	27.1	29.5	25.3	20.4	20.7	21.1	22.7	24.7	27.1	29.7	27.1

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<18C	6%	6%	0%	15%	0%	0%	30%	48%	53%	4%	12%	0%	5%	21%
18-20C	6%	33%	3%	46%	0%	0%	68%	40%	28%	23%	19%	34%	18%	30%
20-22C	15%	29%	29%	24%	0%	0%	2%	12%	19%	67%	47%	31%	20%	25%
22-24C	30%	17%	41%	9%	35%	22%	0%	0%	0%	6%	21%	14%	26%	9%
24-26C	32%	9%	17%	4%	34%	78%	0%	0%	0%	0%	1%	14%	19%	13%
26-28C	11%	4%	8%	1%	24%	0%	0%	0%	0%	0%	0%	6%	10%	1%
28-30C	0%	2%	1%	0%	7%	0%	0%	0%	0%	0%	0%	0%	2%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Figure B.2 B.C. Advanced House: SE bedroom temperature

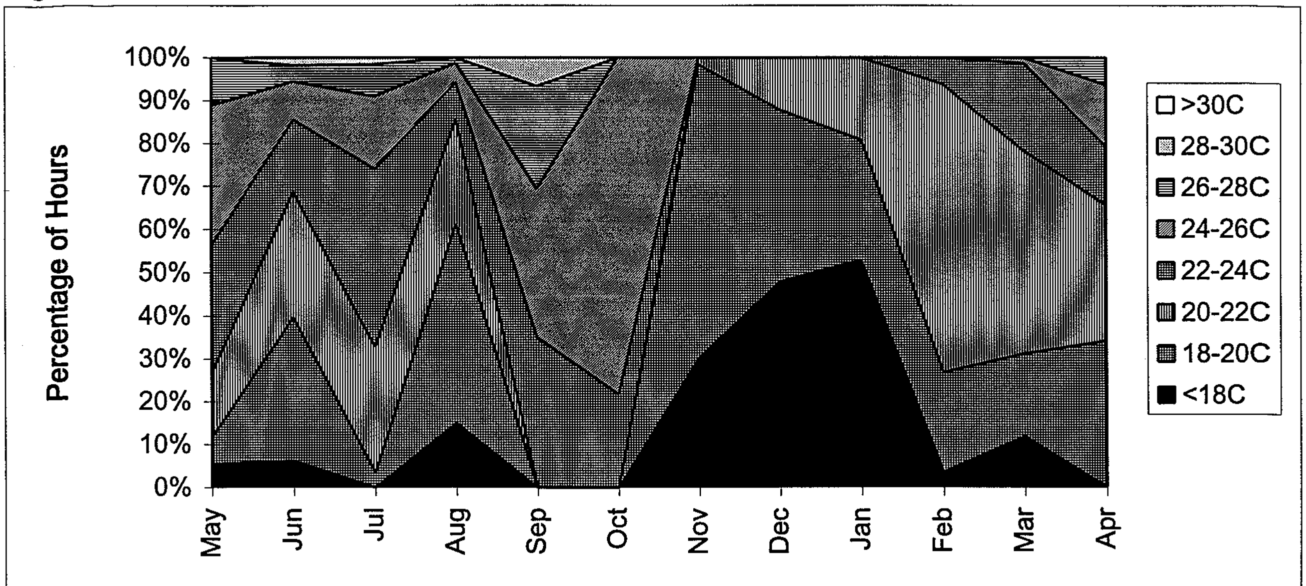


	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr
Average	22.9	21.8	23.7	21.2	23.7	23.7	17.8	18.2	18.3	20.1	19.6	20.2	22.6	19.7
Minimum	17.0	18.0	20.3	18.0	20.3	21.9	14.5	14.8	15.4	16.8	13.9	16.5	17.0	13.9
Maximum	26.3	29.1	28.6	26.8	29.0	25.4	20.8	24.3	22.7	23.4	25.0	25.8	29.1	25.8

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<18C	2%	0%	0%	0%	0%	0%	53%	45%	51%	4%	19%	20%	0%	27%
18-20C	9%	28%	0%	32%	0%	0%	42%	24%	28%	45%	33%	36%	14%	30%
20-22C	13%	29%	14%	37%	28%	2%	5%	30%	21%	44%	40%	18%	24%	23%
22-24C	46%	27%	50%	18%	27%	61%	0%	1%	0%	7%	7%	13%	34%	13%
24-26C	29%	10%	24%	10%	29%	37%	0%	0%	0%	0%	1%	12%	20%	7%
26-28C	1%	5%	10%	2%	12%	0%	0%	0%	0%	0%	0%	0%	6%	0%
28-30C	0%	2%	3%	0%	3%	0%	0%	0%	0%	0%	0%	0%	2%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Figure B.3 B.C. Advanced House: North Study temperature

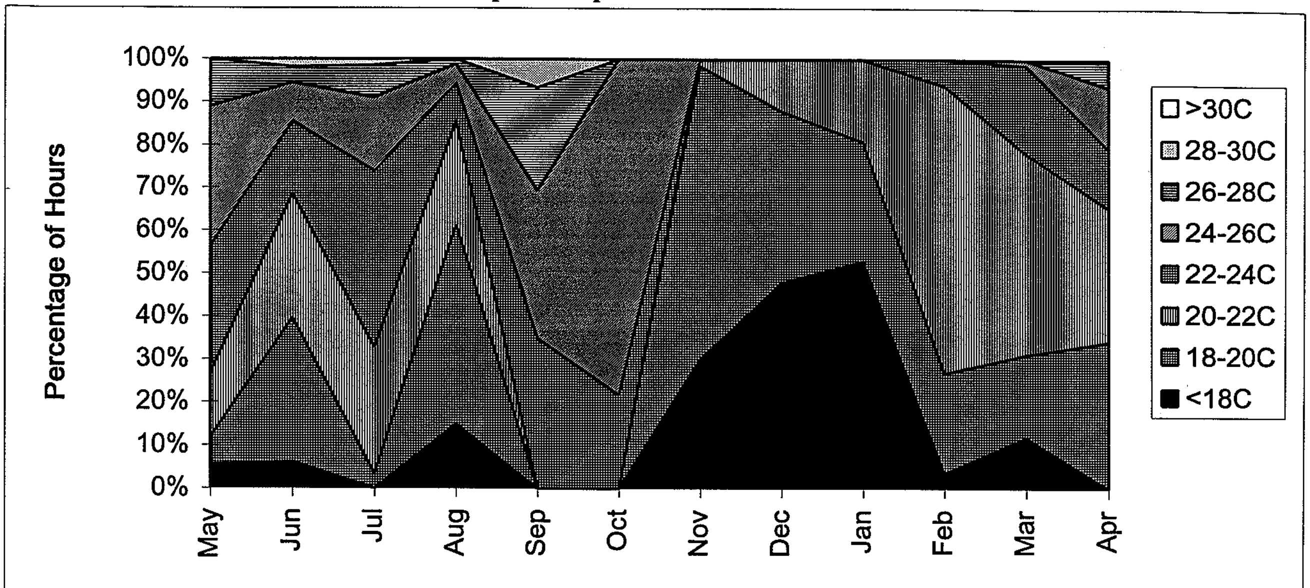


	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr
Average	22.8	21.9	23.9	21.2	23.7	22.9	18.2	18.2	18.2	20.4	19.3	20.0	22.7	19.6
Minimum	17.6	18.5	20.9	18.0	20.8	22.0	15.7	14.3	15.7	17.6	14.1	16.8	17.6	14.1
Maximum	25.3	28.9	28.5	26.6	27.7	23.7	20.7	21.2	21.7	22.2	22.4	25.1	28.9	25.1

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<18C	1%	0%	0%	0%	0%	0%	37%	46%	56%	2%	22%	23%	0%	27%
18-20C	9%	21%	0%	28%	0%	0%	60%	20%	23%	16%	34%	37%	12%	27%
20-22C	12%	33%	9%	43%	19%	0%	3%	34%	21%	79%	40%	18%	23%	28%
22-24C	52%	30%	53%	17%	35%	100%	0%	0%	0%	2%	4%	12%	37%	17%
24-26C	26%	9%	25%	10%	36%	0%	0%	0%	0%	0%	0%	10%	21%	1%
26-28C	0%	5%	10%	2%	10%	0%	0%	0%	0%	0%	0%	0%	5%	0%
28-30C	0%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Figure B.4 B.C. Advanced House: Crawlspace temperature



	1995 May	Jun	Jul	1995 Aug	1994 Sep	Oct	Nov	1994 Dec	1995 Jan	Feb	Mar	1995 Apr	Summer May-Sep	Winter Oct-Apr
Average	14.6	16.4	18.0	17.3	17.6	16.4	11.9	10.0	9.1	10.7	10.4	11.7	16.8	11.5
Minimum	12.7	15.3	17.1	16.4	16.9	16.3	10.3	9.0	8.2	10.1	9.1	10.7	12.7	8.2
Maximum	17.5	19.8	20.2	19.3	18.4	16.9	13.6	10.8	9.9	11.2	11.7	13.6	20.2	16.9

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<0C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0-5C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5-10C	0%	0%	0%	0%	0%	0%	0%	44%	100%	0%	21%	0%	0%	24%
10-15C	68%	0%	0%	0%	0%	0%	100%	56%	0%	100%	79%	100%	14%	62%
15-20C	32%	100%	99%	100%	100%	100%	0%	0%	0%	0%	0%	0%	86%	14%
20-25C	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25-30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
hrs/month	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

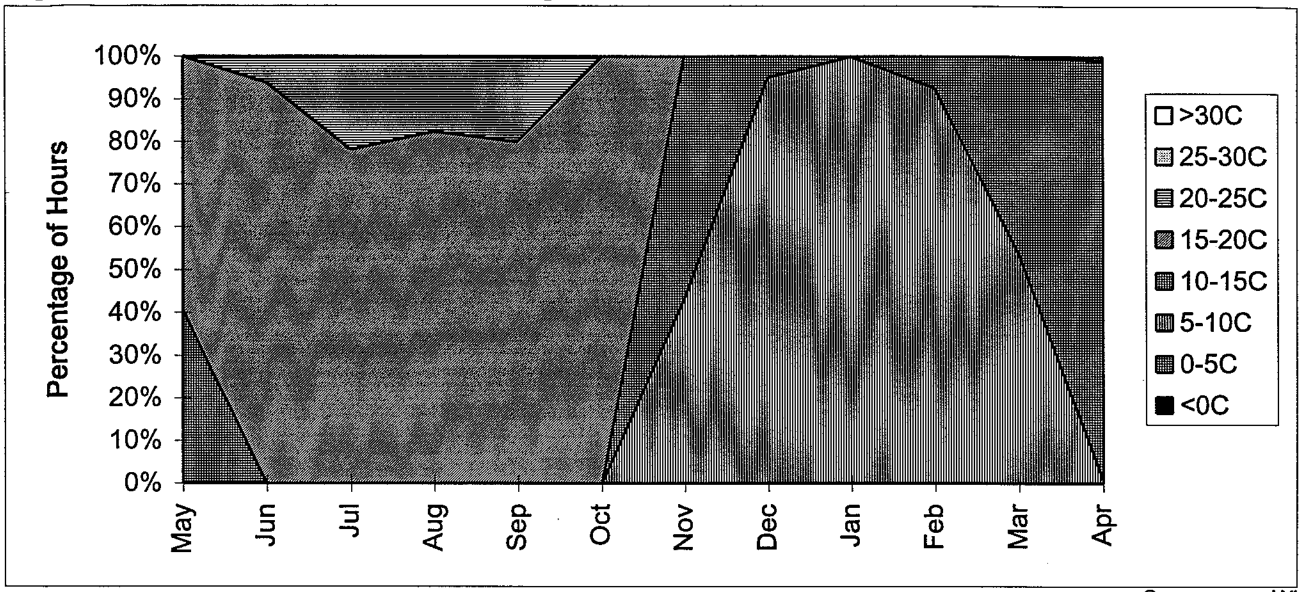
HOT-2000 predicted crawlspace temperatures:

Assuming Unheated, closed (0.1 ac/h ventilation) crawlspace, with RSI 5.64 insulation in floor (none on the ground)
Average Inside temperatures of:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
Tin	23.1	23.1	23.1	23.1	23.1	19.6	19.6	19.6	19.6	19.6	19.6	19.6	23.1	19.6

Tc/s meas.	14.6	16.4	18.0	17.3	17.6	16.4	11.9	10.0	9.1	10.7	10.4	11.7	16.8	11.5
Tc/s pred.	14.4	16.3	17.8	17.8	16.0	12.5	9.9	8.4	7.4	8.5	9.3	11.2	14.4	7.4
Pred-Meas.	-0.2	-0.1	-0.2	0.5	-1.6	**-3.9**	**-2.0**	**-1.6**	**-1.7**	**-2.2**	**-1.1**	**-0.5**	-2.4	**-4.1**

Figure B.5 B.C. Advanced House: Garage temperature



	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Summer May-Sep	Winter Oct-Apr
Average	15.7	17.6	19.5	18.7	19.0	16.7	10.6	8.5	7.3	9.6	9.7	11.6	18.1	10.6
Minimum	12.8	15.1	18.2	16.9	16.3	15.9	8.6	6.8	5.2	9.0	6.8	9.9	12.8	5.2
Maximum	19.5	21.5	21.9	22.9	24.1	19.0	14.8	10.3	9.2	10.0	14.2	15.5	24.1	19.0

Percentage of Hours:

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May-Sep	Oct-Apr
<0C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
0-5C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5-10C	0%	0%	0%	0%	0%	0%	43%	95%	100%	93%	54%	1%	0%	55%
10-15C	41%	0%	0%	0%	0%	0%	57%	5%	0%	7%	46%	98%	8%	30%
15-20C	59%	94%	78%	82%	80%	100%	0%	0%	0%	0%	0%	1%	79%	14%
20-25C	0%	6%	22%	18%	20%	0%	0%	0%	0%	0%	0%	0%	13%	0%
25-30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
>30C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
sum	677	720	411	566	558	46	707	743	444	164	726	715	80%	70%

Outside temperature (C):

Average	15.6	17.6	19.2	16.3	16.1	12.4	4.4	3.9	3.1	7.0	7.2	10.2	17.0	6.9
Minimum	5.1	9.7	10.9	9.7	9.1	6.7	-2.7	-7.0	-5.4	1.8	-2.7	1.9	5.1	-7.0
Maximum	26.8	32.5	31.8	27.1	25.7	19.7	10.5	12.1	10.0	13.3	20.9	22.7	32.5	22.7

Weighted Inside Temperature (C):

Tin	23.3	22.1	24.2	21.5	24.2	23.9	17.7	17.6	17.8	19.7	20.0	20.8	23.1	19.6

Buffering; Tin - Tgarage (C):

dTig	7.6	4.5	4.7	2.9	5.2	7.2	7.1	9.1	10.4	10.2	10.3	9.1	5.0	9.1
dTig/dTio	100%	99%	94%	55%	64%	63%	54%	66%	71%	80%	81%	87%	82%	72%

APPENDIX C: SPOT TESTS

Table C.1 B.C. ADVANCED HOUSE: AIR FLOWS

Main Circulation:

	Air delivery Zone				Supply Outlet Location* Flow (L/s) First floor						Second floor						Hot-wire Anemometer Duct Traverse*** Zone				
Test	Main	Media	Bdrms	Study	Living	Dining	Entry	Main Zone	Family	M.Bdrm.	SE bdrm.	SW bdrm.	Bdrm.Zone	Study	SUM	Main	Family	Bedrooms	Study	Total
1	**open**	min.	**open**	min.	33	23	26	**82**	39	16	36	29	**81**	39	**241**					
				% of SUM:	*14%*	*9%*	*11%*	***34%***	*16%*	*7%*	*15%*	*12%*	***34%***	*16%*						
2	**open**	min.	min.	min.	46	29	32	**107**	39	13	26	23	62	39	**247**					
				% of SUM:	*19%*	*12%*	*13%*	***43%***	*16%*	*5%*	*11%*	*9%*	*25%*	*16%*						
3	**open**	**open**	min.	min.	46	20	32	**98**	**74**	10	23	23	56	36	**263**	**86**	**104**	27	12	**229**
				% of SUM:	*17%*	*7%*	*12%*	***37%***	***28%***	*4%*	*9%*	*9%*	*21%*	*14%*		*-14%*	*29%*	*-106%*	*-196%*	*-15%*
4	**open**	min.	min.	**open**	33	26	29	**88**	29	13	20	23	56	**55**	**228**	(Cf Supply outlet zone sum measurement)				
				% of SUM:	*14%*	*11%*	*13%*	***39%***	*13%*	*6%*	*9%*	*10%*	*24%*	***24%***						
6	**open**	min.	min.	min.	46	26	32	**104**	39	10	26	23	59	42	**244**					
(same as test #2)				*% of SUM:*	*19%*	*11%*	*13%*	***43%***	*16%*	*4%*	*11%*	*9%*	*24%*	*17%*						

HRV:

		DAS** (L/s)		Exhaust Inlet Location* Flow (L/s) First floor			Second floor			Hood to Sum	
Test		Supply	Exhaust	Kitchen	M. Bath	Utility	E.bath	W.bath	SUM	Hood	Difference
1	Medium	57	**51**	11	8	17	7	8	**51**	**52**	*1%*
			% of SUM:	*22%*	*16%*	*33%*	*14%*	*15%*			
2	High	91	**91**	16	28	15	11	11	**82**	**90**	*9%*
			% of SUM:	*20%*	*34%*	*19%*	*13%*	*13%*			

Kitchen exhaust fan Setting		Hot-wire anemometer traverse (16 point grid across face of inlet)
1	Low	67 L/s
2	Medium	not measured
3	High	95 L/s

Dryer	**Exhaust hood***
Fluff, no heat, no clothes	39 L/s

Note: * Flows based on venturi flow hood (single velocity measurement)
** DAS: Data Acquisition System - flow cal pressure drop measurement in duct
*** circulation fan pressure drop = 66 Pa

APPENDIX D: Monthly Result Summaries

The following are included:

- House documentation

Summaries for the following month are included -

- March, 1995

The following months are available in the separate **B.C. Advanced House Data File**:

- September, 1994
- October, 1994
- November, 1994
- December, 1994
- January, 1995
- February, 1995
- March, 1995
- April, 1995
- May, 1995
- June, 1995
- July, 1995
- August, 1995

Each monthly summary includes anecdotal notes, tables of temperatures, energy balances, power distributions and a energy use breakdown.

Do not over-type cells with equations	**B.C. Advanced House DOCUMENTATION**	File No.	Output units: kWh

HOT-2000 file name AD8UNOCB.hdf

Weather Data for Site *

Monitored from:		
	Jan-94	(unoccupied)
to:	Mar-95	(occupied)
to:	Aug-95	(completion)

Location

Province	B.C.	*
City	Surrey	*
Street address		*
Postal code		*
Telephone		

Altitude: 100 m

Occupancy

	Description	Number				Total Heat Gain (W)	
Adults	sales staff	1	@	0.5	h/d	120	/occ.
Teens			@		h/d	111	/occ.
Children			@		h/d	98	/occ.
Large pets			@		h/d	100	/occ.
Small pets			@		h/d	50	/occ.
	Total People	1				(Seated, Very light work)	
						61%	sensible

(ASHRAE Fundamentals - section 26)

Builder

Builder	Cortez Homes	*
City		
Telephone		

Monitoring Contractor

Monitoring Contractor	Ken Cooper
Company	SAR engineering ltd.
City	Burnaby, B.C.
Telephone	604 525 2239
Monitoring system	Sciemetrics

	Continuous		Maximum	
Power use:	100	W		W

Description

Type	Single Detached *			
Number of storeys	2 storey *			
Wall construction	Stressed skin gables; foam & fiberglass rest *			
Mass level	A: gyproc over wood frame	* SE/S/SW	E/W	NE/N/NW
Solar shading of windows	(decimal)	40% *	25%	20%
Basement	none			
Crawlspace	Cellulose blown floor (RSI 5.6)			
Slab	none			
Heated Floor area		270 m^2		

Unique Features

- Radiant floor heating (kitchen, baths & utility)
- Multi-zone heating & ventilation air supply
- Cooling with 100% outside makeup air
- (pressure relief with automatic skylight)
- Open to ceiling plan using stressed-skin panels
- Integrated space & water heating (condensing blr.)
- Solar DHW
- Recycled products for shingles, patio, deck, etc.)

* HOT-2000 input
boxes = input desired; bold boxes = input required

Do not over-type cells with equations

B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

Thermal Characteristics

	Description	Net Area (m^2)	Gross Area (m^2)	SHG	RSI	UA (W/C)
Ceiling - to attic	used only if measuring temperature in the attic	*			*	0.0
- to outdoors		278.95	279.3 *		7.75 *	36.0
Walls - all		200.07	244.3 *		5.25 *	38.1
to attic						0.0
to garage		20.00			5.14	3.9
to solarium						0.0
Doors - all		3.61 *			1.4 *	2.6
to garage		1.76			1.4	1.3
to solarium						0.0
Overhanging floors - all		41.23 *			6.16 *	6.7
to garage		41.23			6.16	6.7
Unhtd. crawlspace - Walls		39.51 *			0.58 *	68.1
Floor perimeter (1m)		60.02 *			5.64 *	10.6
Floor centre		80.08 *			5.64 *	14.2
Basement - above ground			0.0 *		*	0.0
to unhtd c/s or cold room						0.0
Mitalas Foundation Type:				# corners =	4 #N/A	
Bsmt Wall; 0.6m below grade		*			*	
Bsmt Wall; to floor		*			*	
Floor perimeter (1m)		*			*	
Floor centre		*			*	
Windows - North - total	triple, hard-coat low E, argon filled, wood frame	7.55 *		0.530	0.82 *	9.2
- in basement						0.0
Northeast - total		*			*	0.0
- in basement						0.0
East - total	triple, hard-coat low E, argon filled, wood frame	3.00 *		0.433	0.76 *	3.9
- in basement						0.0
Southeast - total		*			*	0.0
- in basement						0.0
South - total	trpl, low E, argon, wood frame; exc. dbl gl. patio (	22.86 *		0.571	0.76 *	30.0
- in basement						0.0
- to solarium						0.0
Southwest - total		*			*	0.0
- in basement						0.0
West - total	trpl, low E, argon, wood frame; exc. dbl gl. patio (	7.20 *		0.541	0.60 *	12.1
- in basement						0.0
Northwest - total		*			*	0.0
- in basement						0.0
Skylights - Horizontal	(45deg.; half included with south windows)	0.32 *		0.433	0.70 *	0.5
						157.2

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Do not over-type cells with equations

B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

Thermal Characteristics...

House heated volume (including heated basements & crawlspaces)		843.73	m^3*			
House total surface area		704.89	m^2			
Air Tightness	Test date:	16-Nov-92	%Area			
Ceiling leakage area		186.3	40%			cm^2
Floor leakage area		121.0	26%			cm^2
Wall leakage area		163.0	35%			cm^2
Flue leakage area		0				cm^2
TOTAL leakage from fan door test; C (L/sPa^n)		26.88				L/sPa^n
Flow exponent, n =		0.64				
Regression coeff., r^2 =		0.9973				
Local shelter factor	Assumed to be sheltered*	0.9				
Flue shelter factor	Assumed to be unsheltered	1				
Local terrain class	Assumed to be 2*	2				
Eave height		2.5	m	Flue height:		m
Met. Stn. meas. height		6	m	No flue ht. entry = No flue		
Met. Stn. terrain class	Assumed suburban	2				
Equivalent Leakage Area	ELA assumed to be 461 cm^2*	470				cm2
Normalized Leakage Area		0.67				cm2/m2
AirChange at 50 Pa	Assumed to be 1.5 ac/h*	1.4				ac/h
	Test date:					
Tracer gas air-tightness						ac/h

Ventilation

F-326 Requirements	Room descriptions	No.Rooms		Vent./room		Vent. Rate	
Kitchen, living, dining		4	* @	5	L/s =	20.0	L/s
Utility rooms		1	* @	5	L/s =	5.0	L/s
Master bedroom		1	* @	10	L/s =	10.0	L/s
Other bedrooms		3	* @	5	L/s =	15.0	L/s
Bathrooms		4	* @	5	L/s =	20.0	L/s
Other habitable rooms			* @	5	L/s =	0.0	L/s
Basement rooms			* @	10	L/s =	0.0	L/s
		13	rooms			70.0	L/s
						0.30	ac/h

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Do not over-type cells with equations

B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

House Temperatures

Living spaces:

	Monitoring Location Description	Floor	Setpoint		Weight factor	
Above Grade		3		C		
	SE bdrm; sensor on N. wall	2	20.0	C	0.30	
	N study; sensor on E. wall	2	20.0	C	0.10	
		2		C		
	N Family/media room; sensor on S. wall	1	20.0	C	0.20	
	S living room; sensor on N. wall	1	20.0	C	0.30	
	SW M.bdrm; sensor on E. wall	1	20.0	C	0.10	
			20.0	C*	1.00	=1.00: OK
Basement		0		C	0.30	
		0		C	0.30	
		0		C	0.40	
				C*	1.00	

Adjoining Spaces:

	Monitoring Location Description	Setpoint		Weight factor
Crawlspace	unheated; sensor in middle of space		C*	
Cold room			C	
Garage	unheated; North side; sensor on W. wall		C	
Solarium			C	
Solarium				
				0.00

Air Quality

	Monitoring Location Description
Carbon Dioxide	Master bedroom
Carbon Dioxide	Family/media room
Relative Humidity	RH measured in HRV in mech. room
Relative Humidity	

Materials Description - Interior		Area (m^2)	Clad?
Wall material			
Ceiling material			
Subfloor			
Paint - main			
- other			
- trim			
Flooring - main			
- other			
- other			
Cupboards - kitchen			
- bathroom			
Other			

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B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

Appliances

	Description	Energuide (kWh/y)	Fuel	Typical (MJ/day)	(L/day)	Default (MJ/day)	Energy Utiliz.
Refrigerator			E	4.50		4.50	100%
Stove	minimum 4 burners; oven minimum 60 L		G			0.00	90%
Clothes Washer	minimum 60 L		E			0.00	100%
Clothes Dryer	minimum 140 L		G			0.00	20%
Dishwasher	minimum 150 L		E			0.00	100%
Other major appliances:			E			0.00	100%
						0.00	100%
Misc. appliances	Major appliances subtotal:	0	kWh/y			4.50	100%
Television		312	E			3.08	100%
Heat distribution system		193	E			1.90	100%
Vent. & heat recovery		1,359	E			13.39	100%
Vacuum cleaner		96	E			0.95	100%
Clock		96	E			0.95	100%
Iron		90	E			0.89	100%
All remaining			E			0.00	100%
	Miscellaneous subtotal:	2,146	kWh/y			21.15	100%
	(Appliance target 3,838 kWh/y) Appliance Subtotal:	2,146	kWh/y				
Lights		477	E	13.3		13.30	100%
	(Lighting target = 412 kWh/y)						
	All appliances	2,623	kWh/y			38.95	
	Not including Heat distribution & Ventilation	**2.9**	**kWh/d***			MJ/day	
Outdoor		183	E	13.3		13.30	
	Annual outdoor target = 183 kWh	**0.5**	**kWh/d***				

Occupant Energy Gains:

(Sensible heat only)

	Number	Average Hours/day	Energy (MJ/d)	Utiliiz.
Adults, Teens, Children	1	0.5	0.1	100%
Pets	0		0.0	100%
			0.1 MJ/d	

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Do not over-type cells with equations

B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

MECHANICAL SYSTEMS:

Space Heating

Heating Degree Days (Base 18C) 3002 DD18C

	Description	Rated Output		Meas. Output		Efficiency (%)	Fuel
Integrated w/water heat	Moreflow condensing gas water heater	29.3	kW		kW	93%	G
Electric Resistance			kW		kW		E
Furnace			kW		kW		
Other					kW		
Fireplace		6.4	kW		kW	50%	G
Maximum flue temperature (wood only)				200	C		
Water to air heat pump			kW		kW		COP
Water to water heat pump			kW		kW		COP
Ground source heat pump			kW		kW		COP
Ground coils			m				
Compressor			kW		kW		

Space Heating Performance Target 4319 **kWh/y** SVF = 0.729

Make-up air supply ____ cm dia. OF = 0.90 (Occupancy factor)

Space Cooling

Cooling Degree Days (base 18C) 38.3 DD greater than 18C

		kW		COP
		kW		COP

Space Cooling Performance Target 90 **kWh/y**

Collection & Distribution

		Capacity (L/s)	Fuel	Measured		Meas. Input (W)	%space
Distrib. Fan - low speed					L/s	55	100%
Distrib. Fan - high speed		350	E	350	L/s	60	100%
Distrib. Fan - cooling		500		500	L/s	70	100%
pump	fan-coil heating circulation	0.67	E	0.67	L/s	75	100%
pump	radiant heating circulation	1	E		L/s	78	100%
pump			E		L/s		100%
pump			E		L/s		100%
pump			E		L/s		100%
pump			E		L/s		100%

	Fluids:	Fluid density		Fluid Sp.Ht.	
Hydronic heating	Radiant heating: water fluid	1.000	kg/L	4.19	kJ/kgC
Hydronic cooling	Radiant cooling: 40% glycol mixture	1.053	kg/L	3.44	kJ/kgC
Fan-coil heating		1.000	kg/L	4.19	kJ/kgC
Fan-coil cooling		1.000	kg/L	4.19	kJ/kgC
Ground-source HP			kg/L		kJ/kgC

* HOT-2000 input
boxes = input desired; bold boxes = input required
3/13/96

Do not over-type cells with equations

B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

MECHANICAL SYSTEMS...

Ventilation

Exhaust fans: (if no exhaust from space, dò not enter capacity)

	Description	Capacity (L/s)	Fuel	Measured		Meas. Input (W)	%space
- kitchen: low speed	motorized damper interlocked to fan			67	L/s	118	10%
- high speed		100	E	95	L/s	40	
- bath			E		L/s		10%
- bath			E		L/s		10%
- dryer		100	G		L/s		
- central vacuum			E		L/s		0%
- other			PV		L/s		10%

Maximum, non-continuous exhaust: 100 L/s*

	Description	Capacity (L/s)	Measured		Meas. Input (W)	%space
Heat Recovery	dual core, cross-flow	90	50	L/s	100	50%

	Description	Length		Dia. (cm)	RSI
Supply ducts		2.5	m	20	1
Exhaust ducts		2.5	m	20	1

HRV location	(basement or main floor)	Main	Fuel:	E
Defrost		none	Cross - flow separation:	100%

	Description	Capacity		HRV rated Efficiency (%)	
HRV preheat - electric			W		(0C)
- hydronic			L/h		(-25C)

Humidification	Description	Capacity		Capacity		Fraction unaccounted
			L/d		W	20%

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B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

Domestic Hot Water

	Description	Capacity				Efficiency (%)	Fuel
	(Enter integrated system Capacity in Space heating section ONLY)						
Water heater - gas/elect.	integrated space + DHW system		kW				
- heat pump				RSI		UA (W/C)*	UAmea
Tank		180	L		Cm2/W	3.00	
Pipes					Cm2/W		

	Design		Typical output		% to space
Water use	315	L/d*		L/d	15%
Setpoint	50	C		C	

	Description	Capacity				Typ. Input (W)	%space
tank location	(basement or main)	main					
pump			L/s		L/s		80%

	Description	Capacity		RSI		UA	
Solar water heating - tank		180	L		Cm2/W	3.0	W/C*
- location	(basement or main)	basement		% heat loss to space:		100%	

	Description	Capacity		orientation			
- solar collectors		6.0	m^2	South	45	degrees slope	
- shading			%	Typical output		Typ. input (W)	%space
- pump to DHW			L/s		L/s		80%
- pump to collectors			L/s		L/s		80%
- photovoltaic system			m^2	Fluid density		Fluid Sp.Ht.	
- fluid to collectors	30% glycol mixture			1.053	kg/L	3.66	kJ/kgC
System		CSIA rated output:			GJ/y*		

	Description	Capacity		Typical output		Typical Input (W)	%space
Grey water heat recovery			L				
pump			L/s		L/s		80%

Water Heating System Performance target 5520 kWh/y

Photovoltaic System

	Description	Capacity		Design output		Orientation	
Panels	40 panels	0.1	m^2		South	45	deg.
Shading		0	%				
Batteries			kWh				
Inverter	none	0	kW				
System					kWh/y		
Load	yard watering pump (from cistern)						

Wind System

	Description	Capacity		Design output	
Wind turbine			kW		
Obstructions					
Batteries			kWh		
Inverter			kW		
System					kWh/y

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B.C. Advanced House DOCUMENTATION

File No.

Output units: kWh

LONG-TERM WEATHER DATA:

Month Number	Month	Horizontal Insolation (MJ/m2d)	Bright RH (%)	Outside Temp. (C)	Degree Days Heating DD18C)	Degree Days Cooling (DD18C)	Wind (m/s)
1	January	2.83	84%	3.0	466	0	3.3
2	February	5.73	82%	4.7	376	0	3.3
3	March	9.90	78%	6.3	363	0	3.6
4	April	15.03	75%	8.8	276	0	3.6
5	May	20.12	73%	12.1	183	0	3.1
6	June	21.01	73%	15.2	89	4	3.1
7	July	22.77	74%	17.2	40	16	3.1
8	August	18.20	75%	17.4	36	16	3.1
9	September	13.53	80%	14.3	113	2	2.8
10	October	7.13	84%	10.0	249	0	3.1
11	November	3.45	83%	6.0	360	0	3.3
12	December	2.21	86%	3.5	451	0	3.3
	YEAR	11.86		9.9	3,002	38	3.2
	years of record	20		30	30	30	30

Source: HOT-2000 <<<<<<Vancouver Airport (1961 - 90) >>>>>>

* HOT-2000 input
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SAR engineering ltd.
8884 - 15th Ave., Burnaby, B.C. V3N 1Y3
Ph. 604 - 525 2239 Fax. 604 - 525 2146

B.C. Advanced House Monitoring Report

MARCH, 1995

The site was visited 1-Apr-95 to collect data.

Operation: The house had 'simulated' occupancy from March 8th to 13th (with testing prior to the 8th).

Hot water consumption	64 L/d		215 L/d during 'simulated' occupancy		
Utilities consumption	9.2 kWh/d		14.4 kWh/d during 'simulated' occupancy		
Inside temperature	20.0 C (space-weighted avg.		20.5 C during 'simulated' occupancy		
HRV operation:			Natural	Balanced	Total
Exhaust	45.2 L/s	'occupied':	0.13	0.20	0.33 ac/h
Supply	49.9 L/s		30	47	77 L/s

The mechanical system was in heating mode.
Water heater turned to 52C; Thermostats set up to 20C; Radiant heating system under CEBUS control
The solar DHW system was not operating (solar contribution shown due to mains water warming in the tank).
The month was slightly warmer than long-term, but otherwise typical.

Over the month:

The space and DHW water heater gross efficiency averaged about 90%
HRV sensible efficiencies averaged 79% (core) and 74% (system)

Data Completeness:

Temperatures	98%	The data logger was down to 1800 on March 1st.
IAQ (RH, CO_2)	98%	
Energy Supplies	98%	

Space Heat Loss Breakdown:

Floors	10%
Ceiling	15%
Walls	16%
Windows	23%
Doors	1%
Infiltration + Ventilation	33%
Humidification	2%
	100%

Space heating coil temperature drop reduced by 0.1C to correct for system efficiencies greater than 100%

The dishwasher was controlled by the CEBUS system to repeat its 'Rinse and Hold' cycle in order to simulate hot water use.
(Rinse and Hold lasts 12 minutes/cycle and consumes 11.5 L/cycle)
Utilities consumption was simulated by an 835 W CEBUS controlled heater (media room) and a 120 W timer controlled light (office)

B.C. Advanced House

MARCH, 1995 Month: **15**

OPERATING CONDITIONS:

	Horizontal Insolation (MJ/m2)	Degree Days Heating base<18C)	Degree Days Cooling base>18C)	Outside Temp. (C)	Outside RH (%)	Inside Temp.# (C)	Inside RH (%)	Garage Temp. (C)	rawlspace Temp. (C)	Family Rm CO2 (ppm)
AVERAGE	9.5	11	0	7.2	71%	20.0	39%	9.6	10.4	419
Daily Min.	0.0	5	0	-0.2	58%	15.3	29%	7.2	9.3	374
Daily Max.	18.0	18	1	13.4	83%	22.6	47%	12.4	11.5	540
Hourly Min.				-2.7		13.9	28%	6.8	9.1	369
Hourly Max.	2.6			20.9		26.9	50%	14.2	11.7	744
Sum		335	1							
Long Term Avg	9.9	363	0	6.3	78% <<compare with boxed values above					

SUPPLIES:

	Electrical (kWh) Total	Space + DHW	Utilities	Outside	Fuel (kWh equivalent) Total	Space + DHW	Fireplace	Water (L) Total	Hot	Outside
peak hourly	3.04			0.39	3.59	3.59	0.00		59.2	
per month	631	159	285	112.1	605	605	0		1,989.5	
per day (DAS)*	20.3	5.1	9.2	3.61	19.5	19.5	0.0		64.2	
per day (Meter)	20.5			3.71	19.2	19.9	0.0	74.0	64.1	0.0
DAS/.Meter	99.4%			97.5%	101.8%	98.0%			100.1%	

SPACE HEATING ENERGY BALANCE:

	SUPPLIES: Appl. (kWh)	Ventil. (kWh)	Space (kWh)	Solar*** (kWh)	LOSSES: Floor (kWh)	Abv. Fdtn. (kWh)	Infil.+Ventil. (kWh)	Humidification (kWh)	Total (kWh)	Buffering (kWh)
AVERAGE	14	17	16	26	7	40	23	1	72	4
Daily Min.	9	9	8	0	4	29	15	1	55	-3
Daily Max.	31	22	34	54	10	60	32	2	90	11
SUM*	434	522	489	797	228	1,249	727	36	2,241	128

Solar SUM calculated from Insolation: 977 kWh (does not include effect of overhangs, blinds or curtains)

MECHANICAL SYSTEMS:

	DHW and Space Heating Demand: Hot Water (kWh)	Space (kWh)	Net Efficiency	HRV: Fan Energy (kWh)	Sensible HRV Efficiency	Sensible System Efficiency	Ventilation Air: Balanced Exhaust Ventilation (L/s)	(ac/h)	Natural Infiltration	Total Ventilation
AVERAGE	2.7	13.5	90%	2.9	79%	74%	45	0.193	0.078	0.285
Daily Min.	0.0	6.7	54%	1.2	74%	66%	20	0.085	0.032	0.150
Daily Max.	9.5	31.1	134%	3.3	85%	79%	52	0.223	0.213	0.446
SUM	85.2	420		90						

	Domestic Hot Water System: Hot Water Demand (L)	Cold Inlet Temp. (C)	Solar out Temp. (C)	Hot Water Temp. (C)	Solar System: Preheat to Tank (kWh)	% of DHW Demand	Cooling system: time on (hr)	Energy supplied (kWh)	COP: Heat removed (kWh)
AVERAGE	64.2	7.2	15.4	41.9	0.5	19.7%	0	0.0	0.0
Daily Min.	0.0	6.8	12.0	43.9	0.0	11.5%	0	0.0	0.0
Daily Max.	222.1	17.0	21.8	45.0	2.6	40.2%	0	0.0	0.0
SUM	1,989				15.4		0	0.0	0

NOTES:

* Supplies per day for DAS (Data aquisition System) & Meters may be for slightly different time periods (depending on date & time of meter reading)

** SUMS in the energy balance are the number of days in the month multiplied by the daily average (therefore, the sum of the components may not exactly equal the total shown for months with incomplete records).

***Calculated from difference of Total losses and Sum of known supplies (compare SUM with Solar SUM from insolation).

\# Based on space-weighted averages (except for hourly, which are minimum and maximum of 5 zones)

B.C. Advanced House — MARCH, 1995 — Month: 15

Detailed Inside Conditions

Inside Temp.	(%of hours monitored in each band)					Inside RH		Inside CO2		
	M.Bdrm	SE.Bdrm	Study	Family Rm	Living Rm.		RHexh		M.Bdrm	Family Rm
<18C	13.1%	18.7%	21.8%	12.0%	16.4%	<20%	0.0%	<350		0.0%
18C - 20C	22.0%	32.5%	34.2%	19.3%	30.3%	20% - 30%	6.1%	350 - 450		85.4%
20C - 22C	45.3%	40.2%	40.5%	47.0%	39.8%	30% - 40%	36.2%	450 - 550		8.8%
22C - 24C	14.3%	7.2%	3.6%	20.5%	9.6%	40% - 50%	57.3%	550 - 650	missing	4.7%
24C - 26C	4.5%	1.4%	0.0%	1.2%	3.2%	50% - 60%	0.4%	650 - 750		1.1%
26C - 28C	0.7%	0.0%	0.0%	0.0%	0.7%	60% - 70%	0.0%	750 - 850		0.0%
28C - 30C	0.0%	0.0%	0.0%	0.0%	0.0%	70% - 80%	0.0%	850 - 950		0.0%
>30C	0.0%	0.0%	0.0%	0.0%	0.0%	>80%	0.0%	>950		0.0%
Hrs. monitored	726	726	726	726	726		726		0	726
Completeness	98%	98%	98%	98%	98%		98%		0%	98%

Average Power Profiles:

	Electrical:			Natural Gas:		Combined:
Hour	Outside Average (kW)	Total Electrical Average (kW)	Std. Dev. (kW)	Space + DHW (kW)	Total Gas Average (kW)	Total Energy Average (kW)
1	0.15	0.73	0.09	0.56	0.52	1.24
2	0.15	0.71	0.06	0.53	0.49	1.20
3	0.15	0.74	0.10	0.68	0.63	1.37
4	0.15	0.72	0.08	0.61	0.56	1.28
5	0.15	0.73	0.09	0.51	0.47	1.19
6	0.15	0.75	0.10	0.85	0.78	1.53
7	0.15	0.78	0.12	0.94	0.87	1.64
8	0.15	0.97	0.28	1.26	1.16	2.13
9	0.15	1.04	0.30	1.35	1.25	2.29
10	0.15	0.85	0.17	0.98	0.91	1.76
11	0.15	0.81	0.13	0.94	0.87	1.67
12	0.15	0.85	0.19	1.00	0.93	1.78
13	0.15	0.87	0.20	0.94	0.87	1.74
14	0.16	0.93	0.20	0.83	0.76	1.69
15	0.16	1.08	0.31	0.73	0.67	1.75
16	0.16	1.06	0.32	0.73	0.67	1.73
17	0.16	0.83	0.18	0.74	0.69	1.52
18	0.15	0.78	0.15	0.65	0.60	1.38
19	0.15	0.90	0.24	0.69	0.64	1.54
20	0.15	0.96	0.25	1.17	1.08	2.05
21	0.15	0.95	0.27	0.87	0.80	1.75
22	0.16	0.85	0.18	0.79	0.73	1.58
23	0.16	0.78	0.13	0.51	0.47	1.25
24	0.15	0.71	0.06	0.62	0.58	1.28
Max. hourly	0.39	3.04		3.59	3.59	
Time of max.		hr. to 1600				

Data completeness:	Hours monitored	Temperatures	IAQ (RH, CO2)	Energy Supplies
	97%	98%	98%	98%

B.C. Advanced House   MARCH, 1995   Month: 15

Energy Supplies

	Refrigerator (kWh)	Electricity Stove (kWh)	Gas Stove (kWh)	Dishwasher (kWh)	Washer (kWh)	Gas Dryer (kWh)	Lights (kWh)	Outdoors (kWh)	Electricity TOTAL (kWh)	Gas TOTAL (kWh)
AVERAGE	1.21	0.30	0.0	0.45	0.00	0.0	2.12	3.6	20.3	19.5
Daily Min.			0.0			0.0		1.7	13.7	9.7
Daily Max.			0.0			0.0		8.0	39.1	40.5
peak hourly			0.000			0.000		0.390	3.041	3.585
Monthly SUM	37	9	0	14	0	0	66	112	631	605
Source:	Manual	Manual	DAS	Manual	Manual	Manual	Manual	DAS	DAS	DAS

Notes: Energy supplies based on Manual meter readings are for the calendar month, based on 30.83 days, up to 1500 1-Apr-95

Monthly End-Use Summary:

End-Use			Energy Consumption (kWh)	Fuel	% of Total	Remarks
House Total	Electricity		**631**	Electricity	**51.0%**	measured
	Gas		**605**	Gas	**49.0%**	measured
		Total	**1,236**	Mix	**100.0%**	sum of electricity and natural gas
Integrated Heating System			**733**	Mix	**59.3%**	sum of components
	Space & Water Heating		605	Gas	49.0%	measured
	Parasitic Loads		**64**	Electricity	**5.2%**	sum of components
		Gas water tank	0.3	Electricity	0.0%	measured
		Pumps	22.8	Electricity	1.8%	calculated from on-time
		Circulation fan	41.0	Electricity	3.3%	by calculation (on 100% of time)
Ventilation	HRV fans		**90**	Electricity	**7.3%**	measured
Lighting and Appliances			**285**	Electricity	**23.0%**	by subtraction
Outside			**112**	Electricity	**9.1%**	measured

Notes: House unoccupied, except for 'simulated' occupancy from March 8th to 13th.
Heating system set to 52C, thermostats set to 20C.
System in heating mode

DAILY SUMMARY Operating Conditions | **B.C. Advanced House** | **MARCH, 1995**

Day	Mo.	Yr.	Wind (AES) (m/s)	Insolation (MJ/m2)	(hr)	Outside Temp. (C)	(hr)	Heating Degree Day (DD<18C)	Cooling Degree Day (DD>18C)	Outside RH (%)	(hr)	Crawlspace Temp. (C)	(hr)	Garage Temp. (C)	(hr)	Inside Temp. (C)	(hr)	Inside RH (%)	(hr)	Day of Week
1	Mar	95	2.9	0.0	*6*	7.3	*6*	10.7	0.0	59%	*6*	9.9	*6*	8.4	*6*	22.1	*6*	29%	*6*	*Wed*
2	Mar	95	2.3	12.4	*24*	4.4	*24*	13.6	0.0	70%	*24*	9.9	*24*	8.2	*24*	22.4	*24*	29%	*24*	*Thur*
3	Mar	95	2.1	12.6	*24*	3.5	*24*	14.5	0.0	78%	*24*	10.0	*24*	8.1	*24*	22.4	*24*	30%	*24*	*Fri*
4	Mar	95	4.2	4.8	*24*	2.8	*24*	15.2	0.0	80%	*24*	9.8	*24*	8.0	*24*	21.1	*24*	31%	*24*	*Sat*
5	Mar	95	2.9	4.7	*24*	-0.2	*24*	18.2	0.0	81%	*24*	9.3	*24*	7.2	*24*	19.0	*24*	30%	*24*	*Sun*
6	Mar	95	1.6	8.6	*24*	1.1	*24*	16.9	0.0	83%	*24*	9.3	*24*	7.3	*24*	19.4	*24*	31%	*24*	*Mon*
7	Mar	95	2.2	11.3	*24*	4.3	*24*	13.7	0.0	71%	*24*	9.5	*24*	7.7	*24*	20.3	*24*	32%	*24*	*Tues*
8	Mar	95	4.1	1.2	*24*	4.9	*24*	13.1	0.0	70%	*24*	10.1	*24*	8.1	*24*	19.9	*24*	34%	*24*	*Wed*
9	Mar	95	7.1	4.5	*24*	9.2	*24*	8.8	0.0	65%	*24*	10.6	*24*	9.0	*24*	20.1	*24*	41%	*24*	*Thur*
10	Mar	95	4.9	4.6	*24*	9.1	*24*	8.9	0.0	73%	*24*	10.9	*24*	10.8	*24*	20.9	*24*	44%	*24*	*Fri*
11	Mar	95	5.1	4.4	*24*	9.7	*24*	8.3	0.0	74%	*24*	10.8	*24*	10.4	*24*	20.8	*24*	45%	*24*	*Sat*
12	Mar	95	4.1	8.0	*24*	6.8	*24*	11.2	0.0	82%	*24*	10.7	*24*	10.0	*24*	20.9	*24*	41%	*24*	*Sun*
13	Mar	95	5.8	3.9	*24*	7.8	*24*	10.2	0.0	77%	*24*	10.6	*24*	9.8	*24*	20.7	*24*	40%	*24*	*Mon*
14	Mar	95	5.8	8.2	*24*	9.8	*24*	8.2	0.0	71%	*24*	10.8	*24*	10.4	*24*	20.8	*24*	44%	*24*	*Tues*
15	Mar	95	3.6	10.2	*24*	9.1	*24*	8.9	0.0	70%	*24*	10.7	*24*	10.4	*24*	20.3	*24*	42%	*24*	*Wed*
16	Mar	95	2.6	14.6	*24*	8.9	*24*	9.1	0.0	71%	*24*	10.7	*24*	10.2	*24*	20.8	*24*	41%	*24*	*Thur*
17	Mar	95	1.6	9.0	*24*	10.4	*24*	7.6	0.0	62%	*24*	10.8	*24*	10.4	*24*	20.4	*24*	39%	*24*	*Fri*
18	Mar	95	2.6	8.2	*24*	10.0	*24*	8.0	0.0	69%	*24*	11.0	*24*	10.9	*24*	20.4	*24*	47%	*24*	*Sat*
19	Mar	95	3.6	8.9	*24*	8.2	*24*	9.8	0.0	77%	*24*	10.9	*24*	10.6	*24*	19.9	*24*	44%	*24*	*Sun*
20	Mar	95	9.6	11.3	*24*	8.8	*24*	9.2	0.0	68%	*24*	10.7	*24*	10.3	*24*	19.3	*24*	42%	*24*	*Mon*
21	Mar	95	7.3	5.5	*24*	7.3	*24*	10.7	0.0	69%	*24*	10.4	*24*	10.1	*24*	18.2	*24*	41%	*24*	*Tues*
22	Mar	95	3.3	5.5	*24*	5.0	*24*	13.0	0.0	73%	*24*	10.3	*24*	9.5	*24*	16.6	*24*	41%	*24*	*Wed*
23	Mar	95	5.0	6.0	*24*	4.5	*24*	13.5	0.0	73%	*24*	10.1	*24*	9.1	*24*	15.3	*24*	43%	*24*	*Thur*
24	Mar	95	8.2	16.2	*24*	5.1	*24*	12.9	0.0	70%	*24*	9.8	*24*	9.0	*24*	16.1	*24*	42%	*24*	*Fri*
25	Mar	95	1.8	17.7	*24*	5.0	*24*	13.0	0.0	70%	*24*	9.9	*24*	8.8	*24*	17.2	*24*	39%	*24*	*Sat*
26	Mar	95	1.5	17.4	*24*	6.4	*24*	11.6	0.0	69%	*24*	10.2	*24*	9.1	*24*	18.2	*24*	40%	*24*	*Sun*
27	Mar	95	1.9	18.0	*24*	8.0	*24*	10.0	0.0	68%	*24*	10.5	*24*	10.1	*24*	19.2	*24*	40%	*24*	*Mon*
28	Mar	95	2.2	17.9	*24*	10.1	*24*	7.9	0.0	66%	*24*	10.8	*24*	10.8	*24*	20.6	*24*	40%	*24*	*Tues*
29	Mar	95	1.7	17.2	*24*	11.0	*24*	7.0	0.0	65%	*24*	11.1	*24*	11.3	*24*	21.6	*24*	40%	*24*	*Wed*
30	Mar	95	1.3	17.6	*24*	13.4	*24*	5.1	0.5	58%	*24*	11.4	*24*	12.0	*24*	22.6	*24*	38%	*24*	*Thur*
31	Mar	95	3.1	5.0	*24*	11.3	*24*	6.7	0.0	60%	*24*	11.5	*24*	12.4	*24*	21.9	*24*	37%	*24*	*Fri*
Average:			3.7	9.5	*23*	7.2	*23*	10.8	0.0	71%	*23*	10.4	*23*	9.6	*23*	20.0	*23*	39%	*23*	
Std.Dev.			*2.1*	*5.4*		*3.1*		*3.1*	*0.1*	*6%*		*0.6*		*1.3*		*1.8*		*5%*		
Minimum:			1.3	0.0	*6*	-0.2	*6*	5.1	0.0	58%	*6*	9.3	*6*	7.2	*6*	15.3	*6*	29%	*6*	
Maximum:			9.6	18.0	*24*	13.4	*24*	18.2	0.5	83%	*24*	11.5	*24*	12.4	*24*	22.6	*24*	47%	*24*	
SUM:								335	0.5											

DAILY SUMMARY

Operating Conditions

B.C. Advanced House

MARCH, 1995

Date Day Mo. Yr.	First floor Temp. (C)	(hr)	(Media rm.) N. side temp. (C)	(hr)	(Living rm.) S. side temp. (C)	(hr)	S. side temp. Temp. swing (C)	Second floor Temp. (C)	(hr)	(Den) N. side temp. (C)	(hr)	(SE bdrm) S. side temp. (C)	(hr)	S. side temp. Temp. swing (C)	M. Bedroom Temp. (C)	(hr)	Family Room CO2 (ppm)	(hr)	
1 Mar 95	22.5	6	22.4	6	22.2	6	1.6	21.5	6	21.2	6	21.7	6	0.8	23.8	6	414	6	Wed
2 Mar 95	22.5	24	22.3	24	22.6	24	6.9	22.2	24	21.4	24	22.4	24	4.3	22.7	24	393	24	Thur
3 Mar 95	22.5	24	22.3	24	22.6	24	6.5	22.3	24	21.5	24	22.6	24	4.1	22.5	24	407	24	Fri
4 Mar 95	21.0	24	21.5	24	20.5	24	1.9	21.3	24	21.3	24	21.4	24	1.4	21.1	24	412	24	Sat
5 Mar 95	18.8	24	19.3	24	18.4	24	1.6	19.3	24	19.4	24	19.2	24	2.2	18.8	24	523	24	Sun
6 Mar 95	19.1	24	19.5	24	18.9	24	3.6	19.8	24	19.2	24	20.0	24	3.3	18.8	24	540	24	Mon
7 Mar 95	20.3	24	20.2	24	20.4	24	5.9	20.3	24	19.5	24	20.6	24	4.3	20.1	24	536	24	Tues
8 Mar 95	19.9	24	20.6	24	19.5	24	1.3	19.8	24	19.8	24	19.8	24	1.0	19.8	24	418	24	Wed
9 Mar 95	20.3	24	21.0	24	19.9	24	2.4	19.9	24	20.0	24	19.9	24	2.6	20.1	24	374	24	Thur
10 Mar 95	21.0	24	21.8	24	20.6	24	1.1	20.8	24	21.0	24	20.7	24	1.2	20.9	24	435	24	Fri
11 Mar 95	20.9	24	21.7	24	20.4	24	1.4	20.6	24	21.0	24	20.4	24	1.4	20.7	24	393	24	Sat
12 Mar 95	21.1	24	21.7	24	20.6	24	2.6	20.6	24	20.9	24	20.5	24	2.2	21.3	24	385	24	Sun
13 Mar 95	20.8	24	21.5	24	20.3	24	1.5	20.4	24	20.7	24	20.3	24	1.6	20.8	24	384	24	Mon
14 Mar 95	21.1	24	21.6	24	20.8	24	3.1	20.3	24	20.4	24	20.3	24	2.0	21.2	24	444	24	Tues
15 Mar 95	20.7	24	21.0	24	20.5	24	2.8	19.6	24	19.4	24	19.7	24	1.8	21.1	24	390	24	Wed
16 Mar 95	21.3	24	21.2	24	21.3	24	5.3	20.1	24	19.4	24	20.3	24	3.7	21.7	24	397	24	Thur
17 Mar 95	20.9	24	21.1	24	20.7	24	2.6	19.8	24	19.4	24	19.9	24	1.6	21.2	24	390	24	Fri
18 Mar 95	20.8	24	21.3	24	20.4	24	2.2	19.7	24	19.6	24	19.7	24	1.6	21.0	24	457	24	Sat
19 Mar 95	20.4	24	20.8	24	20.0	24	1.6	19.3	24	19.2	24	19.3	24	1.1	20.5	24	433	24	Sun
20 Mar 95	19.8	24	20.0	24	19.6	24	3.0	18.6	24	18.4	24	18.6	24	1.8	20.1	24	381	24	Mon
21 Mar 95	18.6	24	19.1	24	18.2	24	1.6	17.5	24	17.5	24	17.4	24	1.6	19.0	24	379	24	Tues
22 Mar 95	17.0	24	17.5	24	16.6	24	1.4	15.9	24	16.0	24	15.9	24	1.4	17.3	24	384	24	Wed
23 Mar 95	15.7	24	16.2	24	15.4	24	0.9	14.6	24	14.6	24	14.5	24	0.8	16.1	24	406	24	Thur
24 Mar 95	16.7	24	16.8	24	16.5	24	4.1	15.3	24	14.9	24	15.4	24	3.1	17.2	24	390	24	Fri
25 Mar 95	17.7	24	17.7	24	17.6	24	5.1	16.5	24	16.0	24	16.7	24	3.9	18.2	24	420	24	Sat
26 Mar 95	18.6	24	18.6	24	18.5	24	4.2	17.5	24	17.1	24	17.7	24	3.3	19.2	24	428	24	Sun
27 Mar 95	19.7	24	19.6	24	19.5	24	4.9	18.5	24	18.0	24	18.7	24	3.4	20.2	24	423	24	Mon
28 Mar 95	21.0	24	20.9	24	20.9	24	5.0	19.9	24	19.4	24	20.1	24	3.5	21.6	24	421	24	Tues
29 Mar 95	22.0	24	22.0	24	21.8	24	4.6	20.9	24	20.5	24	21.1	24	3.3	22.4	24	416	24	Wed
30 Mar 95	23.0	24	23.0	24	22.8	24	4.8	21.9	24	21.4	24	22.1	24	3.3	23.4	24	405	24	Thur
31 Mar 95	22.2	24	22.7	24	21.8	24	2.0	21.4	24	21.4	24	21.4	24	2.0	22.6	24	399	24	Fri
Average:	20.3	23	20.6	23	20.0	23	3.1	19.6	23	19.3	23	19.6	23	2.4	20.5	23	419	23	
Std.Dev.	*1.8*		*1.8*		*1.8*		*1.7*	*2.0*		*1.9*		*2.0*		*1.1*	*1.8*		*43*		
Minimum:	15.7	6	16.2	6	15.4	6	0.9	14.6	6	14.6	6	14.5	6	0.8	16.1	6	374	6	
Maximum:	23.0	24	23.0	24	22.8	24	6.9	22.3	24	21.5	24	22.6	24	4.3	23.8	24	540	24	
SUM:																			

DAILY SUMMARY

Energy Supplies

B.C. Advanced House

MARCH, 1995

Date Day Mo. Yr.	ELECTRIC: Hvac & DHW (kWh)	Utilities (kWh)	Outside (kWh)	(hr)	TOTAL Elec. (kWh)	(hr)	NATURAL GAS: Stove (kWh)	(hr)	Dryer (kWh)	(hr)	Fireplace (kWh)	(hr)	Space + DHW Total (kWh)	(hr)	TOTAL Gas (kWh)	(hr)	
1 Mar 95	4.02	10.65	1.70	6	18.77	6	0.00	6	0.00	6	0.00	6	21.0	6	21.0	6	Wed
2 Mar 95	4.26	7.11	1.81	24	15.58	24	0.00	24	0.00	24	0.00	24	20.7	24	20.7	24	Thur
3 Mar 95	4.26	7.03	1.80	24	15.49	24	0.00	24	0.00	24	0.00	24	21.2	24	21.2	24	Fri
4 Mar 95	4.27	13.15	2.77	24	22.58	24	0.00	24	0.00	24	0.00	24	31.7	24	31.7	24	Sat
5 Mar 95	4.02	12.97	5.14	24	24.53	24	0.00	24	0.00	24	0.00	24	32.8	24	32.8	24	Sun
6 Mar 95	4.53	25.61	6.52	24	39.06	24	0.00	24	0.00	24	0.00	24	34.8	24	34.8	24	Mon
7 Mar 95	5.41	22.59	6.29	24	36.70	24	0.00	24	0.00	24	0.00	24	24.6	24	24.6	24	Tues
8 Mar 95	5.78	17.13	3.21	24	28.53	24	0.00	24	0.00	24	0.00	24	40.5	24	40.5	24	Wed
9 Mar 95	5.76	17.22	3.75	24	29.13	24	0.00	24	0.00	24	0.00	24	39.2	24	39.2	24	Thur
10 Mar 95	5.72	15.83	4.58	24	28.53	24	0.00	24	0.00	24	0.00	24	32.0	24	32.0	24	Fri
11 Mar 95	5.74	11.89	2.89	24	22.92	24	0.00	24	0.00	24	0.00	24	30.9	24	30.9	24	Sat
12 Mar 95	5.77	12.09	1.78	24	22.04	24	0.00	24	0.00	24	0.00	24	32.3	24	32.3	24	Sun
13 Mar 95	5.77	12.32	1.76	24	22.25	24	0.00	24	0.00	24	0.00	24	34.2	24	34.2	24	Mon
14 Mar 95	5.05	9.64	1.89	24	18.98	24	0.00	24	0.00	24	0.00	24	20.1	24	20.1	24	Tues
15 Mar 95	4.96	4.87	1.79	24	14.02	24	0.00	24	0.00	24	0.00	24	11.3	24	11.3	24	Wed
16 Mar 95	4.95	4.98	1.81	24	14.14	24	0.00	24	0.00	24	0.00	24	10.2	24	10.2	24	Thur
17 Mar 95	4.93	4.89	1.80	24	14.02	24	0.00	24	0.00	24	0.00	24	10.8	24	10.8	24	Fri
18 Mar 95	9.68	5.28	1.96	24	19.33	24	0.00	24	0.00	24	0.00	24	11.0	24	11.0	24	Sat
19 Mar 95	5.01	8.10	1.89	24	17.41	24	0.00	24	0.00	24	0.00	24	10.8	24	10.8	24	Sun
20 Mar 95	4.91	4.77	1.70	24	13.78	24	0.00	24	0.00	24	0.00	24	11.3	24	11.3	24	Mon
21 Mar 95	4.93	4.82	1.67	24	13.82	24	0.00	24	0.00	24	0.00	24	11.3	24	11.3	24	Tues
22 Mar 95	4.96	4.73	1.68	24	13.77	24	0.00	24	0.00	24	0.00	24	12.7	24	12.7	24	Wed
23 Mar 95	4.98	4.62	1.68	24	13.68	24	0.00	24	0.00	24	0.00	24	13.0	24	13.0	24	Thur
24 Mar 95	4.98	4.72	1.69	24	13.79	24	0.00	24	0.00	24	0.00	24	12.4	24	12.4	24	Fri
25 Mar 95	4.99	8.65	3.15	24	19.19	24	0.00	24	0.00	24	0.00	24	11.9	24	11.9	24	Sat
26 Mar 95	5.02	5.61	5.78	24	18.82	24	0.00	24	0.00	24	0.00	24	11.0	24	11.0	24	Sun
27 Mar 95	4.98	4.52	7.89	24	19.78	24	0.00	24	0.00	24	0.00	24	11.3	24	11.3	24	Mon
28 Mar 95	4.95	4.68	7.93	24	19.96	24	0.00	24	0.00	24	0.00	24	10.5	24	10.5	24	Tues
29 Mar 95	4.93	4.68	7.92	24	19.93	24	0.00	24	0.00	24	0.00	24	9.9	24	9.9	24	Wed
30 Mar 95	4.91	4.74	7.95	24	20.00	24	0.00	24	0.00	24	0.00	24	9.7	24	9.7	24	Thur
31 Mar 95	4.91	4.81	7.90	24	20.02	24	0.00	24	0.00	24	0.00	24	9.9	24	9.9	24	Fri
Average:	5.14	9.18	3.61	23	20.34	23	0.00	23	0.00	23	0.00	23	19.5	23	19.5	23	
Std.Dev.	*0.98*	*5.70*	*2.39*		*6.49*		*0.00*		*0.00*		*0.00*		*10.5*		*10.5*		
Minimum:	4.02	4.52	1.67	6	13.68	6	0.00	6	0.00	6	0.00	6	9.7	6	9.7	6	
Maximum:	9.68	25.61	7.95	24	39.06	24	0.00	24	0.00	24	0.00	24	40.5	24	40.5	24	
SUM:	159	285	112		631		0		0		0		605		605		

DAILY SUMMARY Space heat balance	B.C. Advanced House													MARCH, 1995
Date	Space heat Energy Gains (supplies x utilizability):				Solar =	Space heat Energy Losses (calulated):					Buffer	Infiltration (AIM2):	
Day Mo. Yr.	Occ.	Appl.	Ventil.	Space	Loss - Gain	Foundation	Abv. Fdtn.	Infil.+Ventil.	Humidification	Total	effect	stack:wind	Total
	(kWh)	(kWh) *(hr)*	(kWh) *(hr)*	(kWh) *(hr)*	(kWh)	(kWh) %	(kWh) %	(kWh) %	(kWh) %	(kWh) %	(kWh)	(ach)	(ach)
1 Mar 95	0.0	15.6	9.1	9.9	37.5	9.5	47.0	15.0	0.6	72.1	2.5	0.06	0.15
2 Mar 95	0.0	11.5	10.7	13.3	49.7	9.7	56.6	18.4	0.6	85.3	5.9	0.05	0.15
3 Mar 95	0.0	11.4	11.3	13.1	53.5	9.7	59.6	19.5	0.6	89.4	7.0	0.05	0.16
4 Mar 95	0.0	17.5	11.6	24.6	36.3	8.8	57.4	22.8	0.9	90.0	8.0	0.09	0.19
5 Mar 95	0.0	18.3	12.0	24.8	33.8	7.7	60.0	20.5	0.7	88.9	10.6	0.06	0.16
6 Mar 95	0.0	30.8	16.1	26.3	14.4	7.9	57.2	21.8	0.7	87.6	9.3	0.05	0.18
7 Mar 95	0.0	27.3	22.4	19.0	21.0	8.5	50.5	29.8	0.9	89.7	6.6	0.05	0.28
8 Mar 95	0.0	22.7	22.1	31.4	10.8	7.7	47.2	30.9	1.3	87.1	6.8	0.08	0.31
9 Mar 95	0.0	22.7	16.7	33.6	0.0	7.5	34.7	27.6	1.9	71.6	1.4	0.15	0.37
10 Mar 95	0.0	21.4	17.6	29.0	4.3	7.6	37.4	25.4	1.8	72.3	2.7	0.10	0.32
11 Mar 95	0.0	17.3	16.8	18.2	16.2	7.6	35.1	24.2	1.7	68.6	1.5	0.10	0.32
12 Mar 95	0.0	17.6	20.6	21.8	22.4	7.8	44.4	28.8	1.5	82.5	5.4	0.08	0.31
13 Mar 95	0.0	17.8	19.1	23.5	18.6	7.8	40.5	29.3	1.5	79.0	3.8	0.12	0.34
14 Mar 95	0.0	14.4	16.2	23.7	14.6	7.6	34.8	24.9	1.7	69.0	1.3	0.12	0.33
15 Mar 95	0.0	9.4	18.4	9.6	29.6	7.3	35.4	23.0	1.3	67.1	2.2	0.07	0.30
16 Mar 95	0.0	9.5	18.6	9.4	32.0	7.7	37.8	23.0	1.1	69.5	2.5	0.05	0.28
17 Mar 95	0.0	9.4	16.5	9.5	23.3	7.4	31.9	18.6	0.9	58.7	0.4	0.04	0.27
18 Mar 95	0.0	9.4	17.2	17.0	18.0	7.1	32.8	20.0	1.7	61.6	1.4	0.05	0.28
19 Mar 95	0.0	12.7	19.2	9.7	27.7	6.9	37.0	24.1	1.3	69.3	3.8	0.07	0.31
20 Mar 95	0.0	9.4	17.4	10.2	36.2	6.6	33.1	31.7	1.7	73.2	3.0	0.21	0.45
21 Mar 95	0.0	9.5	18.4	10.1	32.0	5.9	34.3	28.4	1.5	70.1	5.1	0.15	0.39
22 Mar 95	0.0	9.5	19.3	11.0	25.3	4.9	36.1	23.1	1.1	65.2	7.4	0.06	0.30
23 Mar 95	0.0	9.5	18.3	11.4	23.4	4.1	33.6	23.9	1.2	62.7	8.2	0.10	0.33
24 Mar 95	0.0	9.6	17.5	11.1	32.9	4.9	34.5	30.4	1.3	71.1	7.6	0.18	0.41
25 Mar 95	0.0	13.4	18.9	11.0	24.4	5.7	38.5	22.7	0.8	67.7	6.5	0.04	0.28
26 Mar 95	0.0	10.3	18.5	10.4	27.3	6.3	37.3	22.2	0.9	66.6	4.9	0.04	0.28
27 Mar 95	0.0	9.1	17.2	10.2	26.9	6.7	35.3	20.8	0.8	63.6	3.3	0.04	0.28
28 Mar 95	0.0	9.2	16.0	9.2	26.3	7.4	33.0	19.5	0.8	60.8	0.9	0.04	0.28
29 Mar 95	0.0	9.1	16.3	9.0	27.4	7.9	33.6	19.6	0.9	61.9	0.2	0.04	0.27
30 Mar 95	0.0	9.1	14.2	8.9	23.0	8.4	29.4	16.8	0.7	55.2	-2.5	0.03	0.27
31 Mar 95	0.0	9.2	17.2	8.4	28.4	7.7	33.6	20.9	1.2	63.3	0.7	0.06	0.29
Average:	0.0	14.0	16.8	15.8	25.7	7.4	40.3	23.5	1.1	72.3	4.1	0.08	0.28
Std.Dev.	*0.0*	*6.0*	*3.1*	*7.7*	*11.2*	*1.3*	*9.2*	*4.4*	*0.4*	*10.3*	*3.1*	*0.04*	*0.07*
Minimum:	0.0	9.1	9.1	8.4	0.0	4.1	29.4	15.0	0.6	55.2	-2.5	0.03	0.15
Maximum:	0.0	30.8	22.4	33.6	53.5	9.7	60.0	31.7	1.9	90.0	10.6	0.21	0.45
SUM:	1.1	434	522	489	797	228	1,249	727	36	2,241	128		

DAILY SUMMARY

Heat Recovery Ventilator

B.C. Advanced House

MARCH, 1995

Date Day Mo. Yr.	Supply out flow (L/s)	(hr)	Exhaust in flow (L/s)	(hr)	Supply core out (C)	(hr)	Supply core dT (C)	Exhaust core in (C)	(hr)	Exhaust core dT (C)	ERV fan (kWh)	(hr)	Imbalance (%)	Sensible efficiency HRV (%)	Sensible efficiency System (%)	Enthalpic efficiency HRV (%)	Enthalpic efficiency System (%)
1 Mar 95	19.8	6	23.5	6	23.3	6	14.8	22.7	6	7.6	1.21	6	-18%	77%	69%	37%	33%
2 Mar 95	20.8	24	25.3	24	23.3	24	16.6	22.8	24	8.7	1.42	24	-22%	74%	66%	39%	34%
3 Mar 95	20.8	24	25.5	24	23.3	24	17.5	22.9	24	9.2	1.42	24	-22%	74%	66%	40%	35%
4 Mar 95	20.8	24	24.9	24	22.5	24	18.0	22.2	24	9.5	1.42	24	-20%	75%	68%	39%	34%
5 Mar 95	20.3	24	24.7	24	20.4	24	19.0	20.1	24	9.8	1.43	24	-22%	74%	67%	39%	34%
6 Mar 95	30.4	24	30.1	24	19.7	24	17.2	20.4	24	10.2	1.92	24	1%	85%	79%	41%	38%
7 Mar 95	56.1	24	46.3	24	18.2	24	13.1	20.4	24	10.5	3.31	24	17%	74%	70%	41%	39%
8 Mar 95	55.9	24	46.4	24	18.6	24	13.1	20.5	24	10.2	3.27	24	17%	75%	72%	39%	37%
9 Mar 95	55.5	24	46.6	24	19.7	24	10.0	20.7	24	7.6	3.25	24	16%	75%	72%	35%	33%
10 Mar 95	55.5	24	46.7	24	20.1	24	10.5	21.2	24	8.0	3.22	24	16%	76%	72%	34%	32%
11 Mar 95	55.5	24	46.5	24	20.1	24	10.1	21.1	24	7.6	3.25	24	16%	75%	72%	34%	32%
12 Mar 95	55.9	24	46.5	24	19.6	24	12.2	21.2	24	9.5	3.27	24	17%	76%	72%	38%	35%
13 Mar 95	55.6	24	46.5	24	19.7	24	11.4	21.1	24	8.8	3.26	24	16%	75%	72%	38%	36%
14 Mar 95	54.1	24	47.2	24	20.4	24	10.0	21.0	24	6.8	3.12	24	13%	77%	74%	33%	31%
15 Mar 95	57.3	24	51.3	24	20.2	24	10.7	20.3	24	5.8	3.28	24	11%	82%	79%	28%	27%
16 Mar 95	57.3	24	51.3	24	20.4	24	10.8	20.7	24	6.1	3.28	24	10%	81%	78%	31%	29%
17 Mar 95	56.8	24	51.3	24	20.5	24	9.7	20.5	24	5.3	3.25	24	10%	81%	78%	29%	28%
18 Mar 95	57.6	24	52.2	24	20.3	24	9.9	20.4	24	5.5	3.29	24	9%	81%	78%	26%	24%
19 Mar 95	57.1	24	51.5	24	19.7	24	11.2	20.0	24	6.2	3.26	24	10%	82%	78%	30%	28%
20 Mar 95	56.9	24	51.4	24	19.3	24	10.1	19.5	24	5.5	3.24	24	10%	82%	78%	29%	27%
21 Mar 95	56.9	24	51.7	24	18.2	24	10.7	18.5	24	5.8	3.26	24	9%	82%	79%	29%	28%
22 Mar 95	57.0	24	51.6	24	16.6	24	11.2	16.9	24	6.2	3.28	24	10%	82%	78%	31%	29%
23 Mar 95	57.1	24	51.6	24	15.3	24	10.5	15.6	24	5.9	3.30	24	10%	81%	78%	31%	29%
24 Mar 95	57.0	24	51.3	24	16.0	24	10.1	16.2	24	5.7	3.31	24	10%	81%	77%	31%	29%
25 Mar 95	57.0	24	51.0	24	16.8	24	10.9	17.2	24	6.3	3.31	24	10%	80%	77%	32%	31%
26 Mar 95	57.9	24	52.3	24	17.8	24	10.6	18.2	24	6.1	3.35	24	10%	80%	77%	32%	30%
27 Mar 95	57.0	24	51.3	24	18.9	24	10.0	19.2	24	5.7	3.30	24	10%	80%	77%	31%	29%
28 Mar 95	56.9	24	51.2	24	20.3	24	9.4	20.5	24	5.3	3.28	24	10%	80%	76%	30%	28%
29 Mar 95	56.9	24	51.2	24	21.3	24	9.6	21.5	24	5.5	3.26	24	10%	80%	76%	30%	29%
30 Mar 95	56.6	24	51.2	24	22.5	24	8.4	22.5	24	4.7	3.23	24	10%	79%	76%	29%	27%
31 Mar 95	56.8	24	51.5	24	21.8	24	10.2	22.1	24	5.7	3.24	24	9%	80%	77%	29%	28%
Average:	49.9	23	45.2	23	19.8	23	11.9	20.3	23	7.1	2.92	23	6%	79%	74%	33%	31%
Std.Dev.	13.9		10.0		2.1		2.9	1.9		1.8	0.73		13%	3%	4%	4%	4%
Minimum:	19.8	6	23.5	6	15.3	6	8.4	15.6	6	4.7	1.21	6	-22%	74%	66%	26%	24%
Maximum:	57.9	24	52.3	24	23.3	24	19.0	22.9	24	10.5	3.35	24	17%	85%	79%	41%	39%
SUM:											90.5						

DAILY SUMMARY

Space Conditioning

B.C. Advanced House

MARCH, 1995

Date Day Mo.	Yr.	Space Heating by Gas Water Tank: Fluid flow (L) (hr)	Supply temp. (C) (hr)	Temp. drop (C) (hr)	(-0.1 C correction) Heating (kWh) (hr)	Energy Supplied: Pump energy (kWh)	(hr)	Fan energy (kWh)	GWT electrical (kWh)	(hr)	GWT gas (kWh)	(hr)	Free Cooling On-time (hr)	Energy supply (kWh)	(hr)	Cooling (kWh)
1 Mar	95	41,160	42.7	0.1	7	1.5	6	1.3	0.01	6	21.0	6	0.0	0.0	24	0.0
2 Mar	95	48,460	42.7	0.2	10	1.5	24	1.3	0.01	24	20.7	24	0.0	0.0	24	0.0
3 Mar	95	48,490	42.7	0.2	10	1.5	24	1.3	0.01	24	21.2	24	0.0	0.0	24	0.0
4 Mar	95	48,800	42.8	0.4	22	1.5	24	1.3	0.01	24	31.7	24	0.0	0.0	24	0.0
5 Mar	95	40,280	42.8	0.5	22	1.3	24	1.3	0.01	24	32.8	24	0.0	0.0	24	0.0
6 Mar	95	40,960	42.8	0.5	24	1.3	24	1.3	0.01	24	34.8	24	0.0	0.0	24	0.0
7 Mar	95	24,840	42.8	0.6	17	0.8	24	1.3	0.01	24	24.6	24	0.0	0.0	24	0.0
8 Mar	95	37,750	42.8	0.7	29	1.2	24	1.3	0.02	24	40.5	24	0.0	0.0	24	0.0
9 Mar	95	37,720	43.0	0.7	31	1.2	24	1.3	0.02	24	39.2	24	0.0	0.0	24	0.0
10 Mar	95	37,020	43.0	0.6	27	1.2	24	1.3	0.01	24	32.0	24	0.0	0.0	24	0.0
11 Mar	95	37,430	42.8	0.4	16	1.2	24	1.3	0.01	24	30.9	24	0.0	0.0	24	0.0
12 Mar	95	37,360	42.8	0.4	19	1.2	24	1.3	0.01	24	32.3	24	0.0	0.0	24	0.0
13 Mar	95	37,520	42.8	0.5	21	1.2	24	1.3	0.01	24	34.2	24	0.0	0.0	24	0.0
14 Mar	95	19,230	43.2	1.0	22	0.6	24	1.3	0.01	24	20.1	24	0.0	0.0	24	0.0
15 Mar	95	11,210	42.9	0.6	8	0.3	24	1.3	0.01	24	11.3	24	0.0	0.0	24	0.0
16 Mar	95	11,130	42.9	0.6	8	0.3	24	1.3	0.00	24	10.2	24	0.0	0.0	24	0.0
17 Mar	95	11,170	42.9	0.6	8	0.3	24	1.3	0.00	24	10.8	24	0.0	0.0	24	0.0
18 Mar	95	11,210	43.1	0.8	11	0.3	24	1.3	0.00	24	11.0	24	0.0	0.0	24	0.0
19 Mar	95	11,100	42.9	0.6	8	0.3	24	1.3	0.00	24	10.8	24	0.0	0.0	24	0.0
20 Mar	95	11,200	42.9	0.7	9	0.3	24	1.3	0.01	24	11.3	24	0.0	0.0	24	0.0
21 Mar	95	11,110	42.9	0.7	8	0.3	24	1.3	0.01	24	11.3	24	0.0	0.0	24	0.0
22 Mar	95	11,190	42.9	0.7	9	0.3	24	1.3	0.01	24	12.7	24	0.0	0.0	24	0.0
23 Mar	95	11,180	43.0	0.7	10	0.3	24	1.3	0.01	24	13.0	24	0.0	0.0	24	0.0
24 Mar	95	11,100	43.0	0.7	9	0.3	24	1.3	0.01	24	12.4	24	0.0	0.0	24	0.0
25 Mar	95	11,190	43.0	0.7	9	0.3	24	1.3	0.01	24	11.9	24	0.0	0.0	24	0.0
26 Mar	95	11,100	43.0	0.7	9	0.3	24	1.3	0.00	24	11.0	24	0.0	0.0	24	0.0
27 Mar	95	11,200	42.9	0.7	9	0.3	24	1.3	0.01	24	11.3	24	0.0	0.0	24	0.0
28 Mar	95	11,160	42.9	0.6	8	0.3	24	1.3	0.00	24	10.5	24	0.0	0.0	24	0.0
29 Mar	95	11,120	42.9	0.6	7	0.3	24	1.3	0.00	24	9.9	24	0.0	0.0	24	0.0
30 Mar	95	11,190	42.9	0.6	7	0.3	24	1.3	0.00	24	9.7	24	0.0	0.0	24	0.0
31 Mar	95	11,090	42.8	0.5	7	0.3	24	1.3	0.00	24	9.9	24	0.0	0.0	24	0.0
Average:		23,441	42.9	0.6	14	0.7	23	1.3	0.01	23	19.5	23	0.0	0.0	24	0.0
Std.Dev.		*14,795*	*0.1*	*0.2*	*7*	*0.5*		*0.0*	*0.00*		*10.5*		*0.0*	*0.0*		*0.0*
Minimum:		11,090	42.7	0.1	7	0.3	6	1.3	0.00	6	9.7	6	0.0	0.0	24	0.0
Maximum:		48,800	43.2	1.0	31	1.5	24	1.3	0.02	24	40.5	24	0.0	0.0	24	0.0
SUM:					420	22.8		41.0	0.26		605		0	0.0		0

DAILY SUMMARY

Water Heating

B.C. Advanced House

MARCH, 1995

Date	Domestic Hot Water Demand							GWT heat loss	Solar DHW preheating				Space Condition.+ DHW		Efficiency	
Day Mo. Yr.	Flow (L)	*(hr)*	Cold temp. (C)	*(hr)*	Hot temp. (C)	*(hr)*	Demand (kWh)	to Space (kWh)	Temperature (C)	*(hr)*	Preheating (kWh)	Solar/Demand (%)	Demand (kWh)	Energy Supply (kWh)	Gross (%)	Net (%)
1 Mar 95	147	*6*	6.8	*6*	44.5	*6*	6.5	2.6	21.8	*6*	2.6	39.6%	16.1	22.5	65%	60%
2 Mar 95	0	*24*		*24*		*24*	0.0	2.0		*24*	0.0		12.5	22.2	60%	56%
3 Mar 95	0	*24*		*24*		*24*	0.0	2.0		*24*	0.0		12.2	22.8	58%	54%
4 Mar 95	40	*24*	6.9	*24*	44.0	*24*	1.7	1.9	21.8	*24*	0.7	40.2%	25.4	33.3	78%	74%
5 Mar 95	161	*24*	7.3	*24*	44.5	*24*	7.0	2.9	19.8	*24*	2.3	33.5%	32.0	34.1	91%	87%
6 Mar 95	157	*24*	7.0	*24*	43.9	*24*	6.7	2.8	15.2	*24*	1.5	22.3%	33.3	36.0	91%	88%
7 Mar 95	86	*24*	6.9	*24*	44.3	*24*	3.8	2.3	14.0	*24*	0.7	19.0%	22.9	25.3	91%	88%
8 Mar 95	219	*24*	7.4	*24*	44.5	*24*	9.5	3.2	12.9	*24*	1.4	15.0%	41.6	41.7	99%	96%
9 Mar 95	209	*24*	7.4	*24*	44.3	*24*	9.0	3.1	12.2	*24*	1.2	13.1%	43.2	40.3	107%	104%
10 Mar 95	219	*24*	7.4	*24*	44.6	*24*	9.5	3.1	12.0	*24*	1.2	12.4%	39.1	33.2	119%	114%
11 Mar 95	211	*24*	7.8	*24*	44.4	*24*	9.0	3.1	12.2	*24*	1.1	12.0%	27.8	32.1	86%	83%
12 Mar 95	222	*24*	8.8	*24*	44.3	*24*	9.2	3.1	12.9	*24*	1.1	11.5%	31.6	33.4	95%	91%
13 Mar 95	208	*24*	7.8	*24*	44.4	*24*	8.9	3.0	12.5	*24*	1.1	13.0%	32.9	35.4	93%	90%
14 Mar 95	99	*24*	8.3	*24*	45.0	*24*	4.2	2.4	12.9	*24*	0.5	12.4%	28.4	20.8	138%	134%
15 Mar 95	0	*24*		*24*		*24*	0.0	2.1		*24*	0.0		10.1	11.7	89%	87%
16 Mar 95	0	*24*		*24*		*24*	0.0	2.1		*24*	0.0		9.8	10.6	96%	93%
17 Mar 95	0	*24*		*24*		*24*	0.0	2.1		*24*	0.0		9.9	11.1	92%	89%
18 Mar 95	11	*24*	17.0	*24*	44.1	*24*	0.3	1.8	20.3	*24*	0.0	12.2%	12.7	11.4	115%	112%
19 Mar 95	0	*24*		*24*		*24*	0.0	2.2		*24*	0.0		10.1	11.1	94%	91%
20 Mar 95	0	*24*		*24*		*24*	0.0	2.2		*24*	0.0		10.7	11.7	95%	92%
21 Mar 95	0	*24*		*24*		*24*	0.0	2.3		*24*	0.0		10.8	11.7	95%	92%
22 Mar 95	0	*24*		*24*		*24*	0.0	2.4		*24*	0.0		11.7	13.0	93%	90%
23 Mar 95	0	*24*		*24*		*24*	0.0	2.5		*24*	0.0		12.2	13.3	94%	92%
24 Mar 95	0	*24*		*24*		*24*	0.0	2.4		*24*	0.0		11.9	12.8	96%	93%
25 Mar 95	0	*24*		*24*		*24*	0.0	2.4		*24*	0.0		11.7	12.2	99%	96%
26 Mar 95	0	*24*		*24*		*24*	0.0	2.3		*24*	0.0		11.1	11.4	100%	97%
27 Mar 95	0	*24*		*24*		*24*	0.0	2.2		*24*	0.0		10.8	11.7	95%	92%
28 Mar 95	0	*24*		*24*		*24*	0.0	2.1		*24*	0.0		9.6	10.8	92%	89%
29 Mar 95	0	*24*		*24*		*24*	0.0	2.0		*24*	0.0		9.4	10.3	95%	91%
30 Mar 95	0	*24*		*24*		*24*	0.0	2.0		*24*	0.0		9.2	10.0	96%	92%
31 Mar 95	0	*24*		*24*		*24*	0.0	2.0		*24*	0.0		8.8	10.3	88%	85%
Average:	64	*23*	7.2	*23*	41.9	*23*	2.7	2.4	15.4	*23*	0.5	20%	18.7	20.3	93%	90%
Std.Dev.	*90*		*2.7*		*0.3*		*3.8*	*0.4*	*3.9*		*0.7*	*11%*	*11.2*	*10.9*	*15%*	*15%*
Minimum:	0	*6*	6.8	*6*	43.9	*6*	0.0	1.8	12.0	*6*	0.0	12%	8.8	10.0	58%	54%
Maximum:	222	*24*	17.0	*24*	45.0	*24*	9.5	3.2	21.8	*24*	2.6	40%	43.2	41.7	138%	134%
SUM:	1,989						85.2	74.6			15.4		580	628	90%	90%

DAILY SUMMARY Free air Cooling			B.C. Advanced House													MARCH, 1995
Date			Inside temperature			Outside temperature				Free air cooling			Negative		Maximum cooling	
Day	Mo.	Yr.	Average		Max. hourly	Average		Min. hourly	Max. hourly	Average	Max. hourly	Min. hourly	Cooling		no negative	base on Tcrawl
			(C)	*(hr)*	(C)	(C)	*(hr)*	(C)	(C)	(kWh)	(kW)	(kW)	(kWh)	*(hr)*	(kWh)	(kWh)
1	Mar	95	22.1	*6*	25.4	7.3	*6*	6.8	8.0	0.0	0.0	0.0	0.0	*0*	0.0	0.0
2	Mar	95	22.4	*24*	26.9	4.4	*24*	0.0	9.5	0.0	0.0	0.0	0.0	*0*	0.0	0.0
3	Mar	95	22.4	*24*	26.2	3.5	*24*	-2.7	10.1	0.0	0.0	0.0	0.0	*0*	0.0	0.0
4	Mar	95	21.1	*24*	22.4	2.8	*24*	0.9	4.4	0.0	0.0	0.0	0.0	*0*	0.0	0.0
5	Mar	95	19.0	*24*	20.7	-0.2	*24*	-2.2	2.4	0.0	0.0	0.0	0.0	*0*	0.0	0.0
6	Mar	95	19.4	*24*	21.9	1.1	*24*	-0.9	4.2	0.0	0.0	0.0	0.0	*0*	0.0	0.0
7	Mar	95	20.3	*24*	23.6	4.3	*24*	-0.2	8.8	0.0	0.0	0.0	0.0	*0*	0.0	0.0
8	Mar	95	19.9	*24*	21.7	4.9	*24*	4.0	6.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
9	Mar	95	20.1	*24*	23.0	9.2	*24*	5.9	14.5	0.0	0.0	0.0	0.0	*0*	0.0	0.0
10	Mar	95	20.9	*24*	23.0	9.1	*24*	7.7	10.9	0.0	0.0	0.0	0.0	*0*	0.0	0.0
11	Mar	95	20.8	*24*	23.0	9.7	*24*	7.7	11.6	0.0	0.0	0.0	0.0	*0*	0.0	0.0
12	Mar	95	20.9	*24*	24.0	6.8	*24*	5.0	9.5	0.0	0.0	0.0	0.0	*0*	0.0	0.0
13	Mar	95	20.7	*24*	22.7	7.8	*24*	5.5	11.0	0.0	0.0	0.0	0.0	*0*	0.0	0.0
14	Mar	95	20.8	*24*	23.0	9.8	*24*	7.4	15.0	0.0	0.0	0.0	0.0	*0*	0.0	0.0
15	Mar	95	20.3	*24*	23.1	9.1	*24*	7.0	12.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
16	Mar	95	20.8	*24*	25.0	8.9	*24*	4.6	13.8	0.0	0.0	0.0	0.0	*0*	0.0	0.0
17	Mar	95	20.4	*24*	22.2	10.4	*24*	6.5	17.2	0.0	0.0	0.0	0.0	*0*	0.0	0.0
18	Mar	95	20.4	*24*	22.9	10.0	*24*	8.0	14.4	0.0	0.0	0.0	0.0	*0*	0.0	0.0
19	Mar	95	19.9	*24*	21.6	8.2	*24*	6.5	10.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
20	Mar	95	19.3	*24*	22.0	8.8	*24*	5.9	12.4	0.0	0.0	0.0	0.0	*0*	0.0	0.0
21	Mar	95	18.2	*24*	19.9	7.3	*24*	5.1	9.0	0.0	0.0	0.0	0.0	*0*	0.0	0.0
22	Mar	95	16.6	*24*	18.2	5.0	*24*	2.4	9.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
23	Mar	95	15.3	*24*	17.1	4.5	*24*	0.9	8.1	0.0	0.0	0.0	0.0	*0*	0.0	0.0
24	Mar	95	16.1	*24*	20.7	5.1	*24*	2.3	8.0	0.0	0.0	0.0	0.0	*0*	0.0	0.0
25	Mar	95	17.2	*24*	21.5	5.0	*24*	0.7	9.9	0.0	0.0	0.0	0.0	*0*	0.0	0.0
26	Mar	95	18.2	*24*	22.4	6.4	*24*	0.8	12.1	0.0	0.0	0.0	0.0	*0*	0.0	0.0
27	Mar	95	19.2	*24*	23.8	8.0	*24*	2.0	14.7	0.0	0.0	0.0	0.0	*0*	0.0	0.0
28	Mar	95	20.6	*24*	25.1	10.1	*24*	3.6	17.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
29	Mar	95	21.6	*24*	25.2	11.0	*24*	4.7	17.9	0.0	0.0	0.0	0.0	*0*	0.0	0.0
30	Mar	95	22.6	*24*	26.5	13.4	*24*	5.8	20.9	0.0	0.0	0.0	0.0	*0*	0.0	0.0
31	Mar	95	21.9	*24*	23.9	11.3	*24*	8.6	15.6	0.0	0.0	0.0	0.0	*0*	0.0	0.0
Average:			20.0	*23*	22.9	7.2	*23*	3.9	11.3	0.0	0.0	0.0	0.0	*0*	0.0	0.0
Std.Dev.			*1.8*		2.2	*3.1*		3.2	4.2	*0.0*	*0.0*	*0.0*	*0.0*		*0.0*	*0.0*
Minimum:			15.3	*6*	17.1	-0.2	*6*	-2.7	2.4	0.0	0.0	0.0	0.0	*0*	0.0	0.0
Maximum:			22.6	*24*	26.9	13.4	*24*	8.6	20.9	0.0	0.0	0.0	0.0	*0*	0.0	0.0
SUM:										0			0		0	0