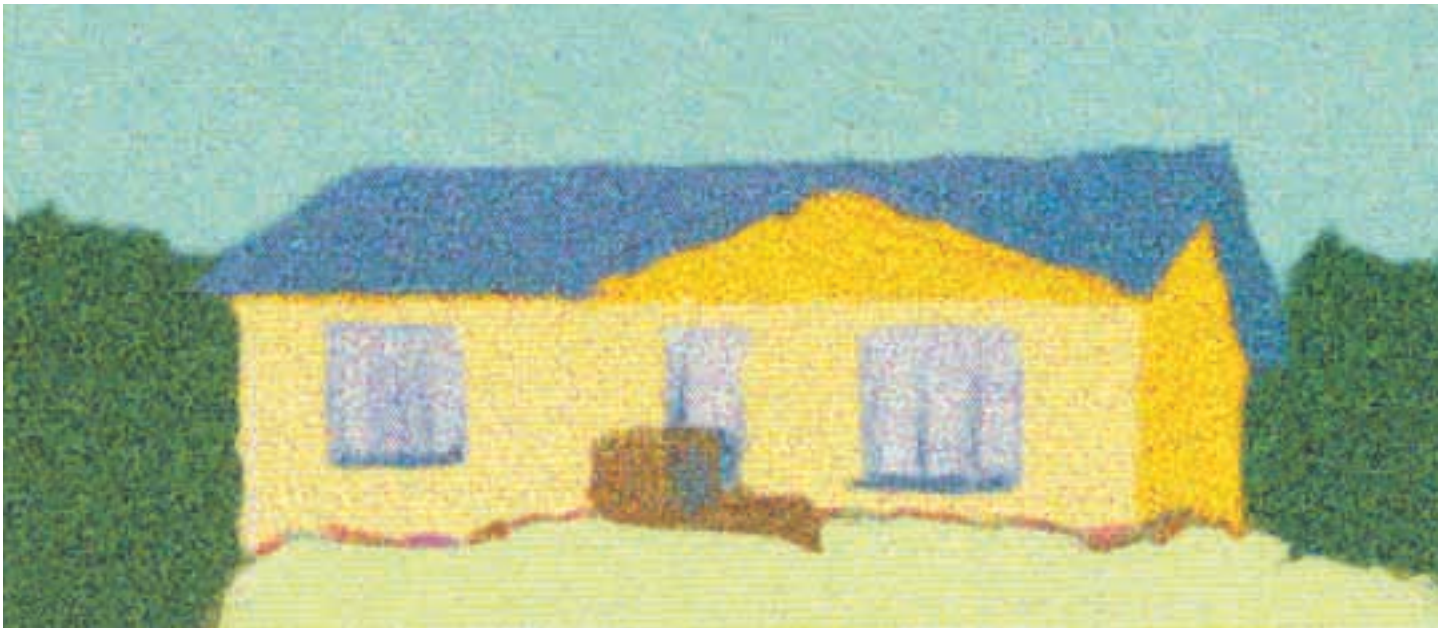
RESEARCH HOUSE FOR THE ENVIRONMENTALLY HYPERSENSITIVE



DESCRIPTION AND TECHNICAL DETAILS

CMHC SCHL

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RESEARCH HOUSE FOR THE ENVIRONMENTALLY HYPERSENSITIVE

Cette publication est aussi disponible en français sous le titre :
Maison de recherche pour les personnes hypersensibles aux polluants environnementaux (61286)

Disclaimer

The house described in the publication is a research house and therefore contains features that have not been thoroughly tested. Although Canada Mortgage and Housing Corporation encourages imitations of the house and its features, all elements of a house must comply with building codes that apply in each location. The Corporation assumes no liability for any damage, injury or expense that may be incurred or suffered as a result of the use of this publication.

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Research House for the Environmentally Hypersensitive

OBJECTIVE OF THIS PROJECT

This prototype house has been designed and constructed to demonstrate and provide an opportunity to evaluate a range of innovative features which can help achieve a clean indoor environment while reducing the cost of housing for people who are environmentally hypersensitive and others who suffer from allergies and respiratory diseases, such as asthma.

HOW THE OBJECTIVE IS ACHIEVED

The clean environment of this house has been achieved through the careful selection of materials and superior ventilation.

The criteria for selection of building materials differ for inside and outside materials. The need for very low emission rates is obviously much greater for the inside materials. In addition, interior finish materials have to be easily cleaned and maintained.

The ventilation system supplies well-filtered air to the bedroom and living room and removes air efficiently from any location that could have an offensive odour or be a source of excessive humidity.

SIGNIFICANCE

CMHC has for years recognized the special housing needs of individuals disabled by environmental hypersensitivities (EH). These people suffer partial to total debilitation, and some are confined to their homes. They require an environment as free as possible from air-borne substances that affect them. Their homes need to be their healthy havens.

Though each individual reacts to a different mix of pollutants, the cleanliness of the air achieved in the CMHC research house should be more than sufficient to meet the indoor air quality needs of the majority of people affected by EH.

There is a real need for research to develop cost-effective housing solutions for people who need clean environments, and thereby to improve their access to suitable housing.

MANAGEMENT AND FUNDING

This project is managed by the Research Division of CMHC. It is one of CMHC's intiatives in support of the National Strategy for the Integration of Persons with Disabilities.

CMHC staff responsible are Peter Russell and Virginia Salares. Consultation on the house design and production was provided by Jamie Cooke, Chief Executive Officer of the Canadian Manufactured Housing Association (CMHA).

HOUSE FEATURES

All the materials in the house are available through building merchants. Reference to specific products and suppliers is for the reader's convenience only.

While particular materials and products have been used, alternatives exist that in other situations can be equally benign, less expensive, durable, easy to maintain, and aesthetically agreeable. Reference numbers throughout the text refer to product information that can be found in Appendix A.

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1. MATERIALS AND COMPONENTS

1.1 Interior Walls and Ceilings

A thin coat of plaster (called veneer plaster)[1] with no additives is applied over "blue board."[2] No paint is required.

Unlike traditional plaster, which is labour-intensive and costly, veneer plaster uses far less material and labour, and is therefore more affordable. In the Maritimes, for example, some custom house builders can finish walls with veneer plaster at the same cost as, or at only slightly higher cost than, with gypsum wallboard with two coats of paint. A plasterer who is skilled with traditional plastering can also do the veneer plastering.

1.2 Utility Room Walls

In the utility room, low-emission paint[3] is used on conventional gypsum board. Dry mix joint compound[4] is used.

Dry mix joint compounds contain fewer preservatives than the more convenient wet preparations.

Unlike most latex paints, the chosen paint has practically no odour, even during application.

1.3 Floor

The tile used throughout the house is set on an acrylic-modified thin-set mortar[5] and furnished with an acceptable grout.[6] The tiles are laid on a 6 mm thick cement-bonded particle board.[7]

The cement-bonded particle board is a rigid, dense sheeting material made of 70% Portland cement and 30% wood. It has very low odour.

Beneath the cement-bonded particle board is the radiant floor heating system described in more detail in Section 2.1.

1.4 Doors

Interior doors are of birch veneer on basswood frames, coated with four coats of acrylic sealant.[8]

This sealant serves to encapsulate odours from the veneer and core materials but it cannot be used on surfaces that are likely to get wet or moist.

Exterior doors are standard steel-clad insulated doors with double-glazed window inserts.

1.5 Trim

Basswood is used, sealed with acrylic sealant.[8]

Sparing use of this sealed wood is acceptable to most sensitive people. Pine is less tolerated.

1.6 Cabinets

Cabinets are built of B.C. fir plywood (softwood). Countertops and shelves are surfaced with a high-pressure laminate, applied with water-based contact cement.[9] All other surfaces and edges are sealed with four coats of acrylic sealant.[8]

The lower cabinet doors and the frames for the glass doors are solid birch finished with two coats of water-based polyurethane,[10] available from paint supply stores.

Note that sufficient coats of the sealant[8] can seal odours and vapours, such as from formaldehyde. However, the water-based polyurethane[10] is intended primarily as a surface finish that resists moisture and therefore permits cleaning with a damp cloth. Though it reduces odour from wood, it may not be effective in sealing vapours from composite wood.

1.7 Bathroom Fixtures

The bathtub is enamelled steel,[11] not plastic.

The sink is also steel,[12] and a low-flush toilet[13] is installed.

The faucets for the sink and bathtub, the slide bar for the shower and the hand shower were supplied by Delta Faucet Canada.

1.8 Windows

The windows have glazing of triple-pane clear glass, argon-filled with thermally efficient edge spacers and insulation-filled fibreglass frames that have a baked enamel finish.[14] Uncoated glass is used rather than coated low-E glazing to provide interior light as much like natural light as possible.

1.9 Refrigerator

To avoid a potential mould problem, water produced during the defrosting process is drained directly to the kitchen sink drain rather than into an evaporator tray under the refrigerator.

The refrigerator[15] is somewhat more energy efficient (48.5 kwh/month) than the average models, which are rated between 53 and 58 kwh/month. Transparent drawers ensure that foods can be checked easily for spoilage. Seamless lining also allows for ease of cleaning.

A recycled refrigerator was ruled out because mouldy smells are common in used refrigerators.

1.10 Stove

The electric stove is self-cleaning rather than continuous cleaning. This avoids uncontrolled emissions which occur each time the latter type is used.

A used stove was purchased from an appliance recycling store.

1.11 Wall Insulation

Rock wool batts [RSI 5.6 (R32)][16] are used for insulation. This material was chosen because its fibres are larger in diameter than in other fibrous insulation materials and are therefore less likely to disperse particulate contaminants into the air.

1.12 Air/Vapour Barriers

Tyvek[17] is the air barrier, and Poly Super 6[18] is the vapour diffusion retarder. Both are available from building supply stores.

1.13 Caulking and Insulation

GE Silicone[19] low-odour caulking is used for doors and windows. Note that GE Silicone II *for bathtub and tile applications* is different from GE Silicone II[19] for doors and windows. The former contains a fungicide while the latter does not.

Cracks between windows and door rough openings and frames are filled with a moisture-curing insulation foam.[20] This low-odour, low-expansion foam must be applied with an applicator gun.

2. MECHANICAL AND ELECTRICAL SYSTEMS

The house is heated by hot water pumped through tubes in the floor (hydronic radiant floor heating). This system is not only economical to run, it also provides comfort and permits the design of a ventilation system that separates the heating from the ventilation. The mechanical system was engineered by Geddes Enterprises of Brampton, Ontario, based on detailed concepts defined by CMHC research staff. Further details are listed in the appendix.[21]

2.1 Heating

Heating and cooling requirements are minimized by high levels of insulation in exterior walls, floor and ceiling, and by orientation of the house so that the largest window area faces south. Energy efficiency is further enhanced with a low air change rate and two-stage heat recovery.

One electricity-powered tank heats water for domestic use and for the hydronic (hot water) radiant floor-heating system, and tempers the ventilation air via a coil between the first and second stages of the heat exchanger.

In comparable houses, water could be heated by gas or oil so long as the appliance is installed in a space completely sealed off from the occupied space. Because the required temperature of water does not exceed 55°C, a condensing gas boiler, ground-source heat pump or district heating would be excellent sources of heat.

Details of the heating system are shown in Figure 10. An antifreeze mixture is pumped through tubing[22] in the floor and is heated via a heat exchanger by water from an electric hot water heater. There are numerous advantages to such a system:

- **Comfortable.** The warm floor radiates heat to the living spaces. This is particularly important with the tile floor.
- **Energy efficient.** For the same comfort level, the space can be maintained at a lower temperature than with forced air heating systems.
- **Quiet.** The electric heater makes no noise and the pump noise is not detectable from the lived-in rooms.
- **Easily cleanable.** There are no radiators that can catch dust.
- **Low operating temperature.** This means that the system is compatible with a wide range of water heating sources: ground source heat pump, condensing boiler, even district heating.
- **Compatible with hard flooring.** Carpets are not installed for air quality reasons, but radiant floor heating will operate more efficiently with uncarpeted floors anyway because carpets act as an unwanted insulation layer.
- **Allows the installation of a very efficient ventilation system.**

Compromises do not have to be made in the design of the ventilation system for it also to act as the heating system, as is normally the case.

Radiant floor heating is more expensive to install than a warm air heating system. However, experience from this installation indicates that the incremental cost need not be large in prefabricated housing.

In a house positioned on a basement, slab or insulated crawlspace, antifreeze would not be necessary.

2.2 Cooling

Cooling loads are minimized by envelope insulation and house orientation, and by the absence of windows in the west wall. A small air-conditioning system cools the coil in the ventilation unit. As air cooled by the coil is reheated in the second stage heat exchange, the net effect is dehumidification rather than cooling. Further space cooling is achieved as piping, installed under the floor tile, cools the floor of the house.

2.3 Ventilation

The prototype ventilation system has been developed to test a combination of features not yet available in any single ventilation appliance. The hope is that its unique combination of features will be recognized by manufacturers as the basis for a commercially available unit. Though designed for this particular application, adaptations of the design would be suitable for any house with radiant floor heating.

The ventilation unit supplies filtered air to the bedroom and living room at about 18°C. The features of the system are illustrated in figures 4 to 11. From those rooms, air moves to the bathroom and kitchen and into closets and cabinets, from which it is extracted. To maintain a comfortable environment in hot weather, the air is dehumidified. Figure 4 shows the main features of the ventilation system.

Ventilation in the bedroom and living room operates quite differently from that which is typical. The method is known as displacement, or stratified, ventilation and is illustrated in Figure 8. Air enters near floor level at a low enough velocity not to cause a draft. This arrangement minimizes air circulation in the space and permits stale or polluted air (air exhaled from room occupants and the air surrounding off-gassing appliances) to rise to the ceiling to be exhausted. Because these pollutant sources are typically warmer than their surroundings, the immediately surrounding air warms and rises. As a consequence, it is possible to achieve the same removal of

air pollutants from a space with a lower than normal air flow, with resultant energy savings. Furthermore, the slow moving air does not stir up as much dust.

2.4 Air Intake/Exhaust Module

The air intake/exhaust module (shown in Figure 5) is mounted on the outside of the utility room. The module ensures separation of intake and exhaust air and contains the first stage filter.

This unit is novel in two respects. The intake and exhaust are usually installed at least 3 metres apart to minimize entrainment of exhaust air into the intake air. The ti design of this module is expected to show that less cross-contamination will occur, even though the intake and exhaust have little separation. In addition, the unit contains the first stage of air filtration, as described in Section 2.6 below.

2.5 The Ventilation Unit

This unique, compact unit is designed to purify air while remaining energy efficient and quiet. Air cleanliness is maintained because all its materials (as described in Section 2.6) and components are odour- and pollutant-free.

Energy efficiency is achieved through high efficiency multi-speed fans[23] and a two-stage air-to-air heat exchange.[24]

2.6 Air Filtration

When the system is operating normally, air supplied to the bedroom and living room passes through two filters. The first, a common, washable “rock catching” filter, made of coarse aluminum mesh, is located outside the house in the intake/exhaust unit. The second, a pleated paper filter,[25] takes out particles down to 0.03 microns with 99.97% arrestance. It is located in the main ventilation unit. Neither of these filters will remove odours, so a third filtering stage comprising four charcoal canisters[26] is also installed in the ventilation unit. This filter offers a large resistance, and considerable fan power is required to maintain air flow. This problem has been overcome through a system design that uses this third filter only when necessary and t with an independent fan. The configuration is shown in Figure 6.

2.7 Other Ventilation System Features

The bedroom is pressurized to guarantee the cleanest possible air. Air is exhausted directly from the kitchen, bathroom, all closets and kitchen cabinets, exterior wall cavity, and multi-purpose cabinet.

The utility room is air-sealed to isolate contaminants and noise.

If air supplied to the living room and bedroom is still not sufficiently pollutant-free despite the various levels of filtration, all or a portion of the air can be further recycled. This is achieved by adjustment of a damper in the ventilation unit (see Figure 6). This feature may be required when there is a brief, excessive odour outside the house.

2.8 Drying Closet

The drying closet, shown in Figure 9, replaces the need for a mechanical clothes dryer. Heat is provided through a copper tubing grill/radiator by the warm water (hydronic) system. Moist air is removed by the ventilation system. This approach does not wear out clothes, reduces electrical energy and power requirements, and avoids static electricity, negating the need for fabric softeners. It's an indoor clothesline! A further advantage over a typical clothes dryer is that the exhaust air is sufficiently lint-free to allow the air extracted from it to exhaust through the heat recovery system.

2.9 Humidifier

There isn't one! We have been unable to find a suitable built-in humidifier. Humidifiers are vulnerable to directly or indirectly generated mould, which, in this house, is absolutely unacceptable. Until a simple, low-cost, readily maintainable humidifier becomes available, we recommend the use of a stand-alone humidifier.

2.10 Stove Hood

An updraft type of stove hood is installed rather than a downdraft exhaust. The latter requires excessive rates of air extraction.

Conventional range hoods require comparatively high rates of air flow to remove cooking odours, sufficient to upset a balanced ventilation system. More efficient hoods are therefore being investigated.

2.11 Water

A separate water supply is installed at the kitchen sink. The choice of water purification device for drinking and cooking to be installed in the utility room will depend on the source of water (city or well) and will be provided by the occupant.

2.12 Light Fixtures

Ceramic sockets instead of plastic (which may off-gas when hot) are installed together with high efficiency, near-full-spectrum light fixtures where practical. The kitchen sink and utility room have l7-watt full-spectrum fluorescent lights[27] instead of 100-watt incandescent bulbs.

2.13 Electromagnetic Fields (EMFs)

The electrical service connects to the house in the least occupied room, the utility room. Although the electrical wiring of the house and the installed appliances generate only low levels of EMF, the house will be checked for EMF levels.

2.14 Noise

The mechanical system has been designed to have an intrinsically low noise level and is located in the utility room — a sealed-off corner of the house. No additional sound-muffling components are included in the design.

There is an insulated double stud wall between the utility room and the bedroom. Each side is part of a different module. This combination of features ensures that only a very low level of sound is transmitted to the bedroom.

3. FURNISHINGS

All furnishings are made from materials that give off as few chemical vapours as possible and are tolerated by people who are environmentally hypersensitive.

3.1 Multi-Purpose Cabinet

A multi-purpose desk and cabinet unit houses a TV and other electronic entertainment equipment that may emit odours, especially when in operation. The cabinet is connected to the air extraction system and is thus depressurized. It may also be adapted to feature a reading unit (a pane of glass over the desk top under which reading matter, such as a newspaper, can be placed). This isolates the odorous print.

The unit is made from formaldehyde-free fibreboard28 and was generously donated by EnviroSafe 2000.[29]

3.2 Sofa

A traditional sofa on solid maple frame. Felt for the upholstery is chemically untreated cotton (no fire retardant). Upholstery fabric is made of cotton and rayon without soil or stain repellant. The sofa was custom-built to detailed specifications.

3.3 Chairs

An antique solid walnut rocker was re-upholstered in the same way as the sofa. The original upholstery and foam filling were replaced with new cotton covering and untreated cotton felt.

3.4 Blinds

Roman blinds are made of cotton duck fabric and cotton lining. Fabrics were pre-washed to remove chemical finishes.

3.5 Bed

This is a solid oak poster bed with a custom-made coil-spring mattress made of chemically untreated cotton felt and pre-washed cotton ticking. Cover, lining and batting of the country quilt[30] are all cotton, washed before assembly. The quilt can be machine washed and dried.

Pillows[31] and bedding are pure cotton.

3.6 Tables, Lamps, and Other Furnishings

The antique round pedestal table in the living room is solid mahogany.

The antique green lamp in the living room is hand blown and hand painted. The Aladdin lamp in the bedroom is another antique. New ceramic sockets and wiring were installed.

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4. HOUSE DESIGN AND CONSTRUCTION

Nearly all the features of this house can be incorporated into other factory or site-built house designs. Many of the features may also be used m house renovations and built into standard housing.

4.1 Factory Construction

This house was built in Quebec in two modules and erected at the temporary location at CMHC's National Office site in Ottawa. (It was built by a housing prefabricator, Les Residences Prince of Princeville, Quebec, a company that is no longer in operation.) It will be divided into its two modules to be transported to a permanent site after the initial evaluation and demonstration phase of the project.

Though there are an increasing number of site-built houses designed or modified to meet the special needs of EH people, there have been no prefabricated houses built

to meet this market, apart from "porcelain" mobile homes in Texas. However, factory-built housing offers some potential advantages for meeting the demand for ultra-clean houses:

- Repeat construction and established sources of special materials can result in production economies and a more affordable house.
- Factory construction permits the consistently high level of quality necessary in such houses.
- Though individual reactions to materials vary considerably, the air quality in this factory-built house meets the needs of all but extreme and unusual cases of EH.

4.2 House Structure

The roof and floor are conventional wood-frame construction. The 25 cm (12 inch) exterior walls are also wood frame but are of an unusual design — all the wall insulation (rock wool batt) is on the outside of the 2 x 4 structural wall. See Figure 2 for details.

4.3 House Orientation

The house is designed so that the front, which has the most window area, faces south to take advantage of solar gain. To minimize summer overheating, south windows have a generous soffit overhang and there are no windows in the west wall.

4.4 House Exterior

The exterior cladding is factory-painted wood hardboard[32] and the roof is pre-painted galvanized steel. The footings are of untreated wood on a crushed stone drainage layer, while the wood foundation walls are protected by a plastic drainage layer[33] covered with a cement-bonded particle board.[7]

5. PERFORMANCE MONITORING

A data-acquisition system monitors air temperature, humidity, air flow rate and air pressure in various locations and verifies how long the system operates in its various modes. It also measures energy usage. These data are transmitted to a remote terminal.

After the house is sold, CMHC will continue to monitor its benefits for the people who use it, as well as any drawbacks, for about two years.

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6. COST

MUP (maximum unit price) is the price limit set by CMHC for a house built to a certain size in a particular location to meet social housing program requirements. For recognized disabilities, including Environmental Hypersensitivity, the MUP is raised 12% to account for the associated additional cost. An objective of this research project is to find ways in which the price of a finished home can be built within the MUP limit.

Like any prototype, this house will cost significantly more than subsequent production models. The cost of constructing this research house was particularly high for the floor, exterior wall, kitchen cabinets, and windows. However, in each of these areas except windows, there are ways of substantially reducing costs, possibly enough to satisfy the MUP requirement. The ventilation equipment has no particularly expensive components. Whether this system becomes generally available will depend on the results of evaluation and on the extent to which manufacturers can be persuaded to use comparable equipment in producing appliances.

APPENDIX A: Sources

Most of the materials or close equivalents are available from building material distributors. However, it may be necessary to shop around or contact manufacturers for some items.

1 Veneer plaster. DOMTAR veneer plaster was used in this application.

2 Blue board. DOMTAR veneer plaster base.

3 Low-emission paint. Glidden Lifemaster 2000, flat.

4 Dry mix joint compound. Rapid 90 drywall joint compound by Westroc Industries.

5 Acrylic-modified thin set mortar. MAPEl Ultra Flex adhesive - MAPEl Inc., Laval, Quebec.

6 Grout. MAPEl KeraColour with Plastijoint.

7 Cement-bonded particle board. Pyroc, distributed by MacMillan Bloedel.

8 The acrylic sealant used for sealing the composite wood surfaces is no longer recommended due to an objectionable odour. If pressed woods are used, seal all the surfaces with laminate before assembly.

9 3M water-based contact cement.

10 Water-based polyurethane. Pierce and Steven's Fabulon Crystal II, satin finish.

11 Enamelled steel bathtub. American Standard Galaxy.

12 Steel sink. American Standard Rondalyn AF 0489.

13 Low-flush toilet. American Standard Cadet III.

14 Triple-pane, argon-filled windows and insulation-filled fibreglass frames. DORWIN windows from Winnipeg. Clear glass from PR Industries Inc., with Edgetech superspacers. Window assemblies supplied by Thermotech Windows Ltd., 109-42 Antares Dr., Nepean, Ontario, tel. 613-225-1101.

15 Refrigerator, AMANA TK 18 .

16 Rock wool batts. Roxul Inc., Milton, Ontario.

17 Air-barrier, Tyvek.

18 Poly Super 6, six mil polyethylene.

19 GE Silicone II for doors and windows (not GE Silicone II for bathtub and tile applications)
An alternative is CSL Silicones 166/343 from Webco Sealants, Guelph, Ontario.

20 Low-expansion, moisture-curing, low-odour foam. Handi Foam Fastfill by Fomo Products, Inc. Norton, Ohio, distributed by BENCO, Québec, Quebec, tel. 418-687-2340.
An alternative is SISTA All-Purpose Foam by Aldon Chemicals, Woodbridge, Ontario.

21 Mechanical systems. Supplied by Geddes Enterprises, Brampton, Ontario.
Subcontractors:
Allen Associates, Toronto. Detailed engineering design.
Ed Lowans, Toronto. Consultant for mechanical systems materials.
Lyle Jori, Toronto. Radiant floor heating.
Maxwell Systems, Bolton, Ontario.

22 Tubing in the floor.

23 Multi-speed fans. McLean Engineering, Camarillo, California, tel. 805-987-5046.

24 Two-stage air-to-air heat exchanger. Maxwell Systems, Bolton, Ontario, tel. 905-951-3500.

25 Pleated paper filter. Rejean Industries.

26 Activated charcoal filter. Air Filter Sales, Concorde, Ontario, tel. 905-669-5470.

27 Ott Capsulite energy-efficient bulbs.

28 Formaldehyde-free fibreboard. Medite II board.

29 EnviroSafe 2000, Burnaby, B.C., tel. 604-298-1050.

30 The Country Quilter, Richmond, Ontario.

31 Pillows. Garnet Hill, Franconia, New Hampshire, tel. 800-622-6216.

32 Exterior cladding. CANEXEL from Canadian Pacific Products.

33 Plastic drainage layer. Platon.

APPENDIX B: Figures

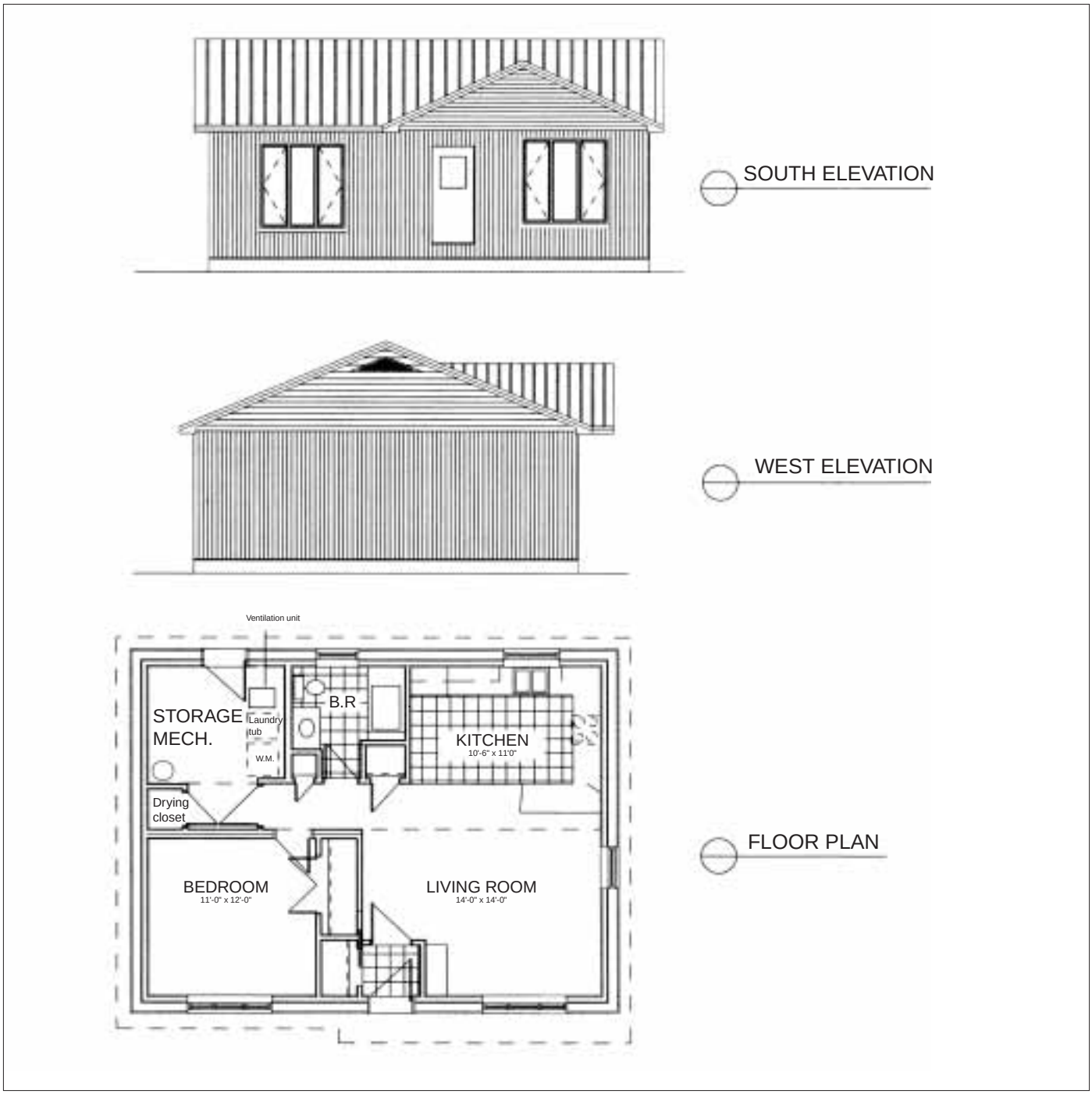

Figure 1 : Elevations and Plan of the House

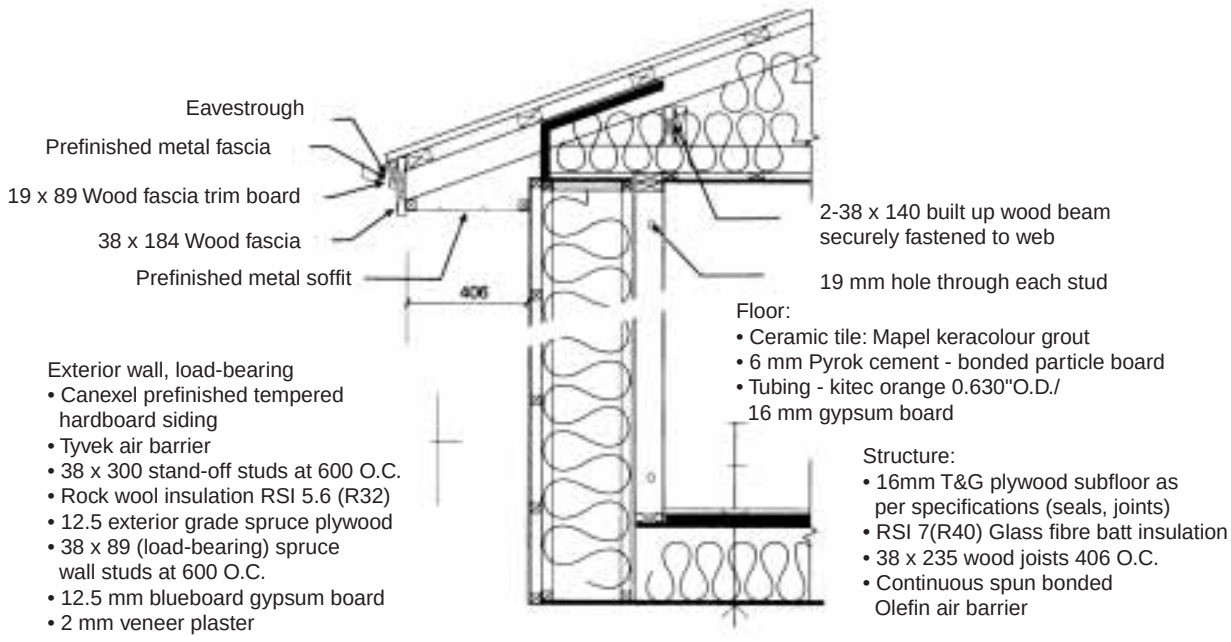

Figure 2 : Wall, Roof and Floor Sections

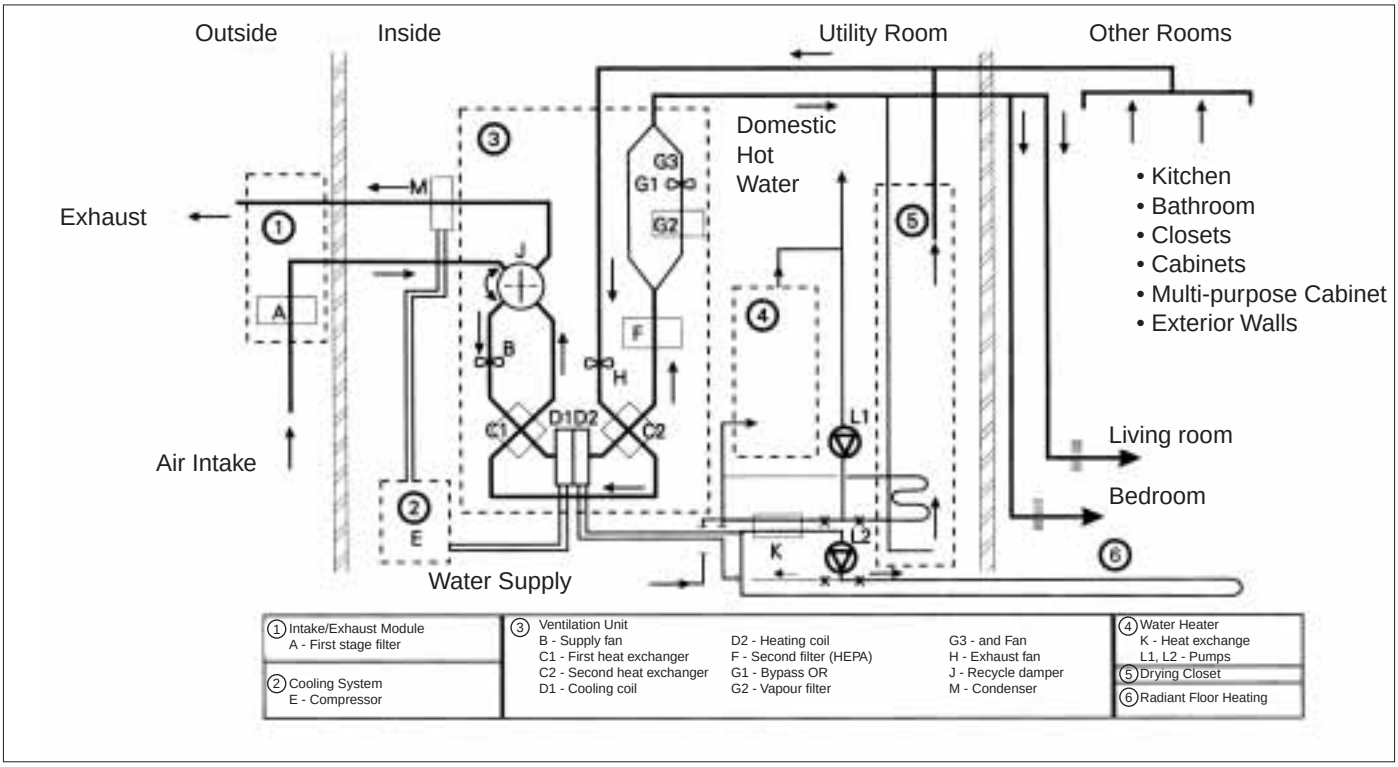

Figure 3 : Ventilation System Schematic

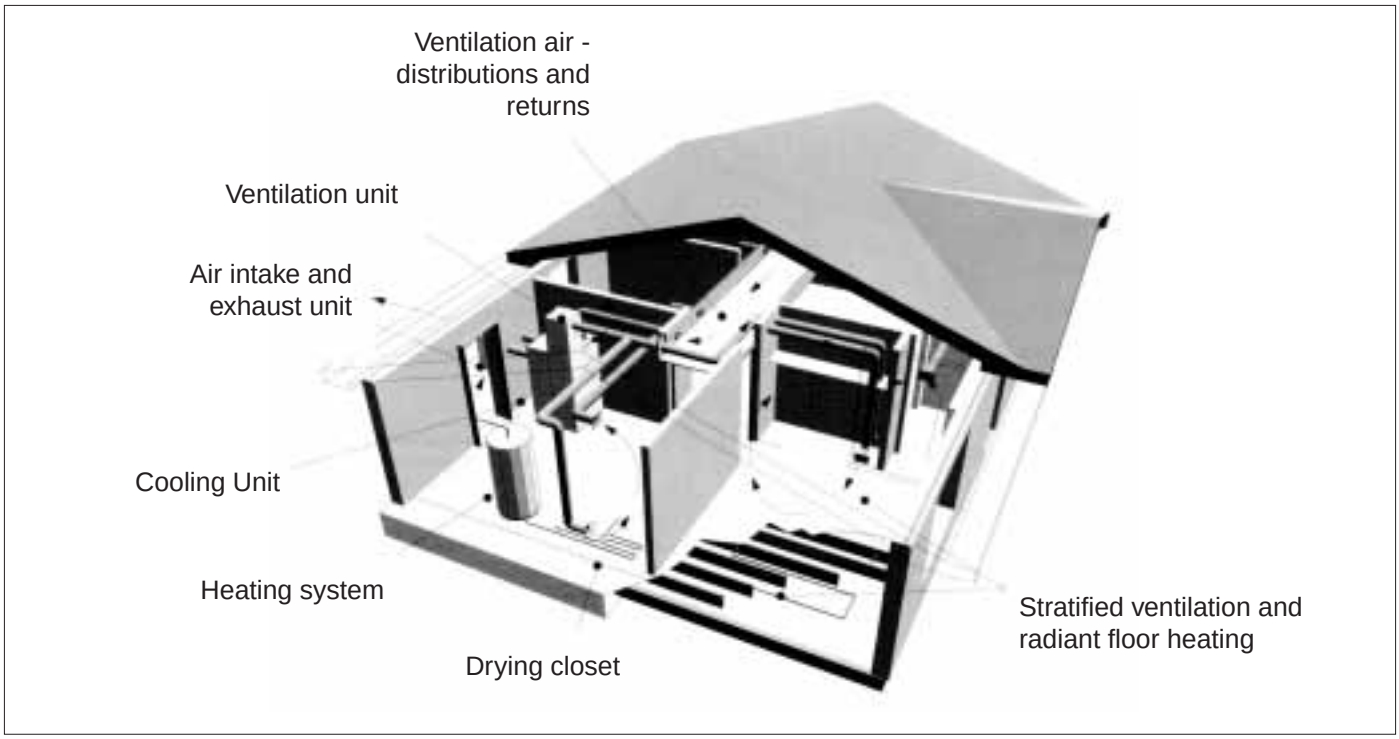

Figure 4 : Ventilation System Layout

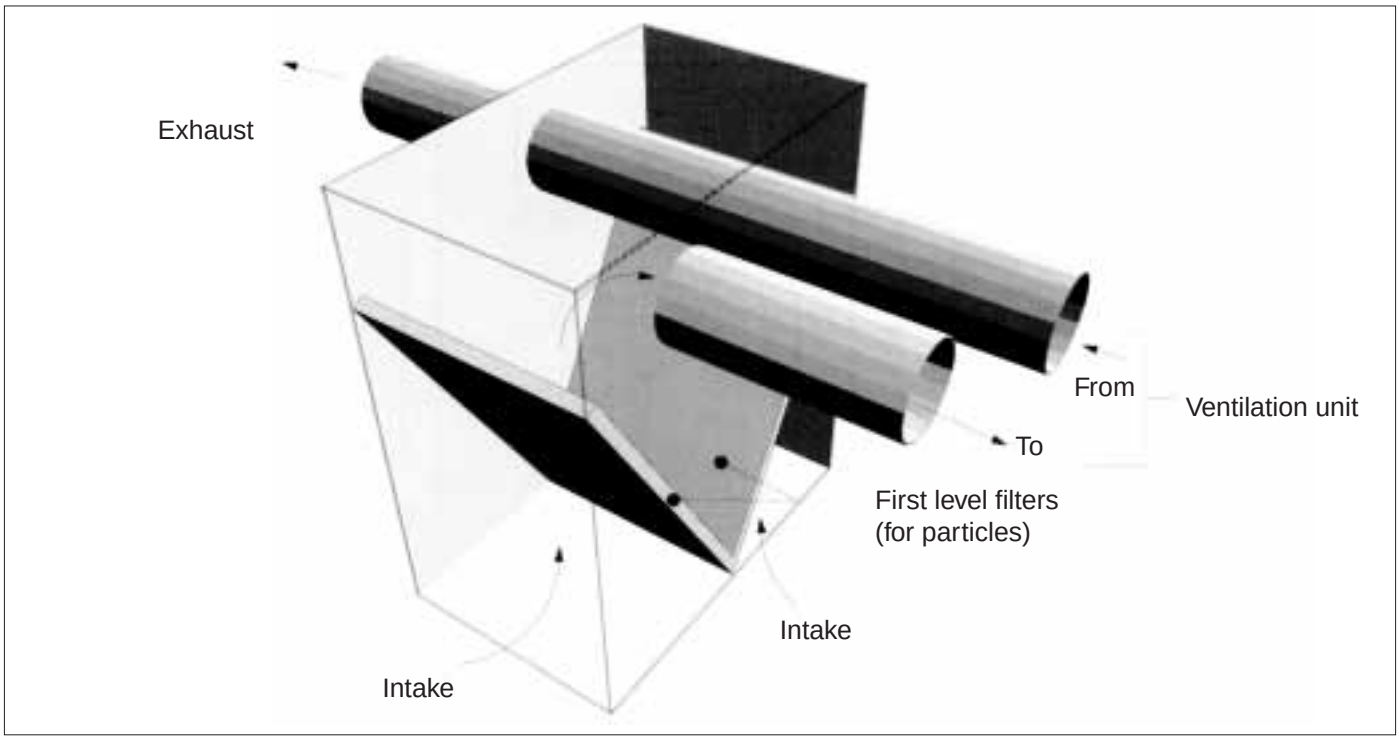

Figure 5 : Air Intake and Exhaust Unit (Located Outside)

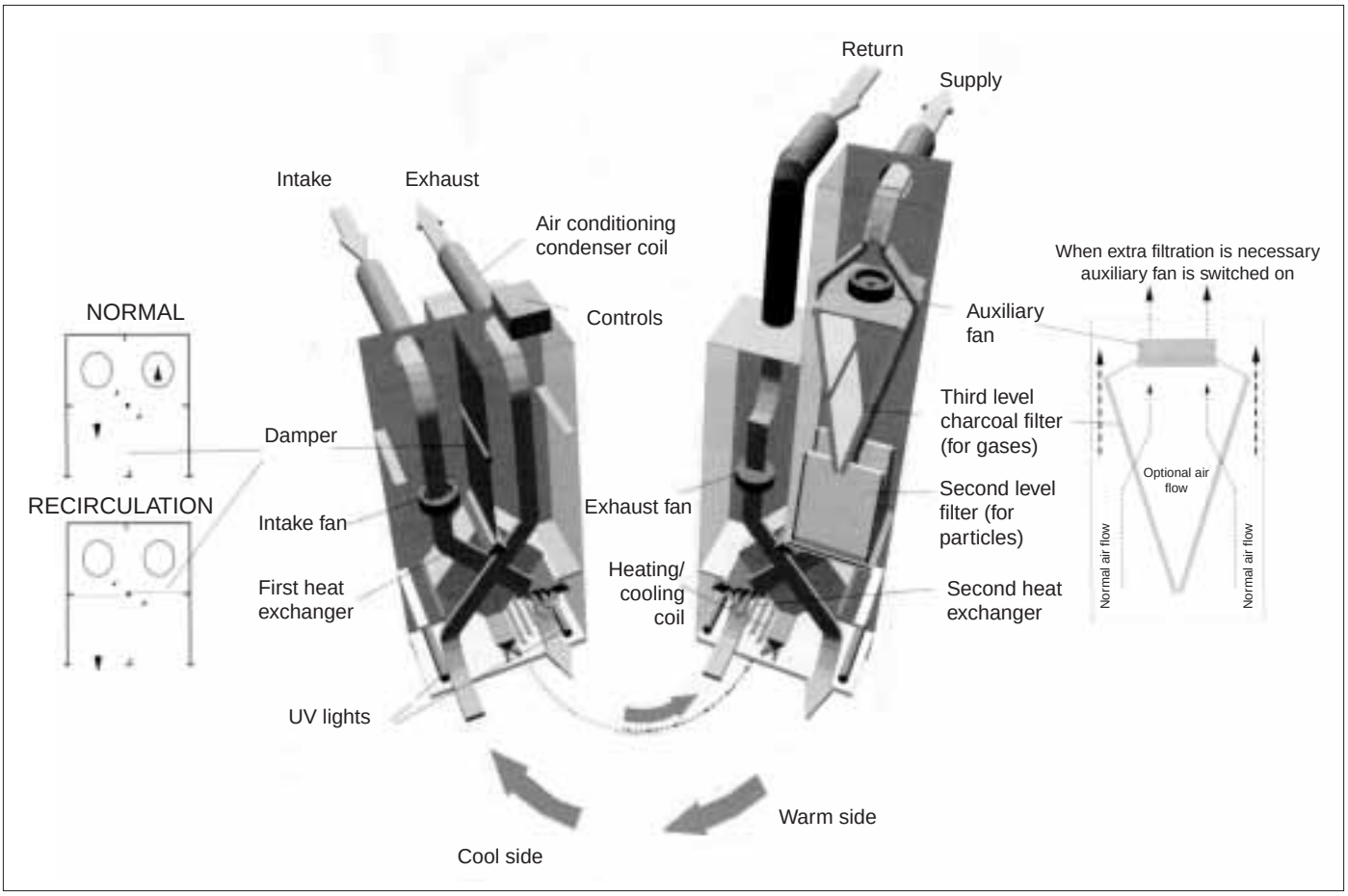

Figure 6 : Ventilation Unit

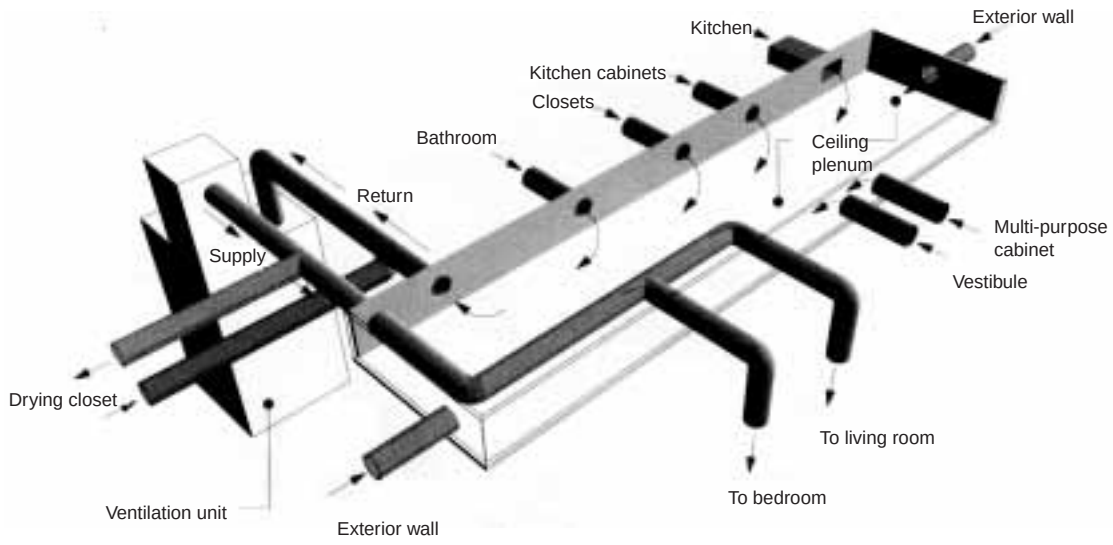

Figure 7 : Ventilation Air — Distribution and Returns

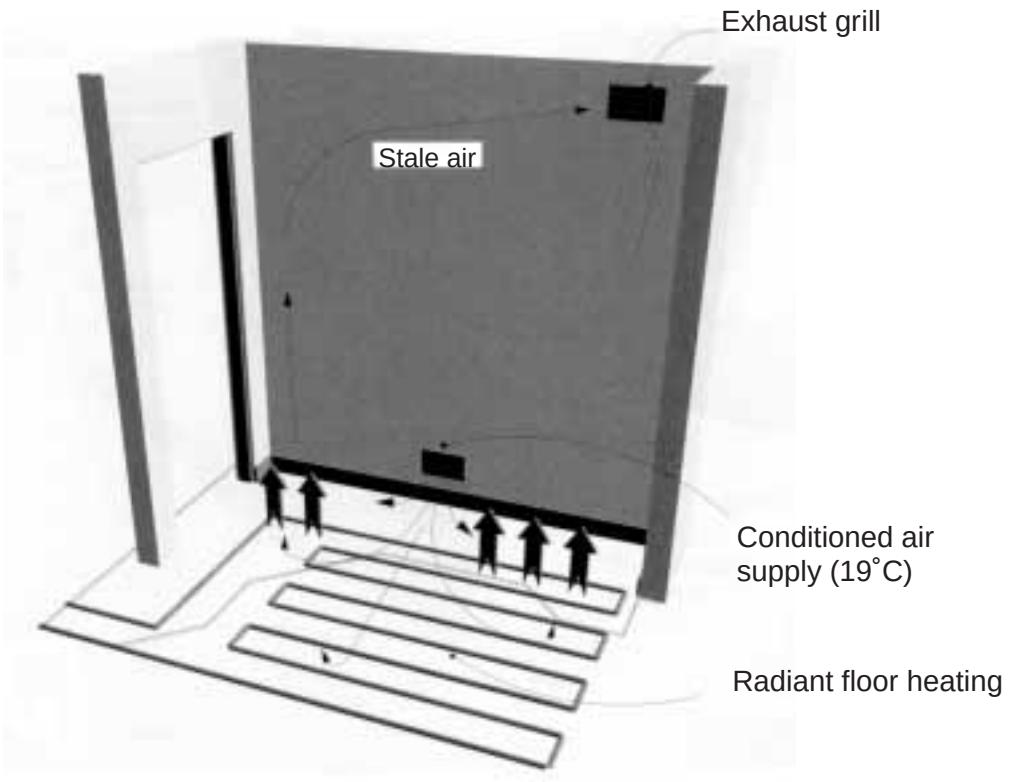

Figure 8 : Stratified Ventilation in Bedroom and Living Room

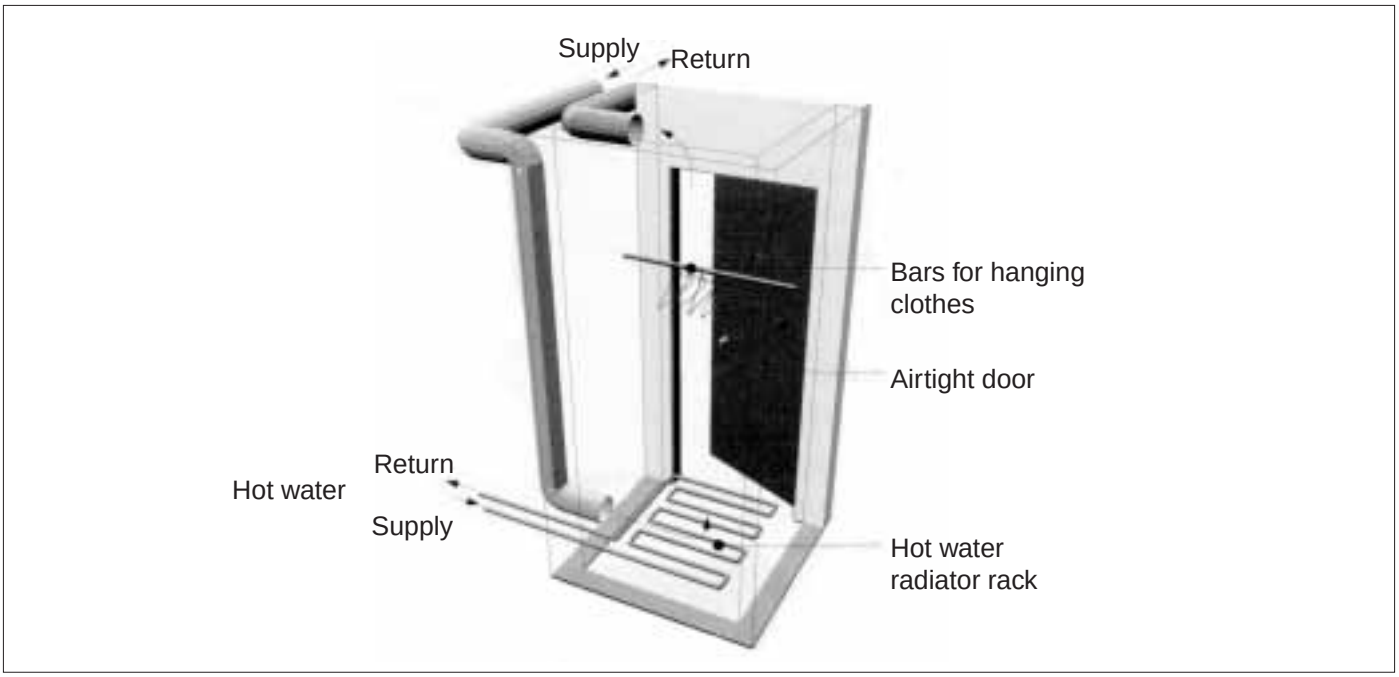

Figure 9 : Clothes Drying Closet

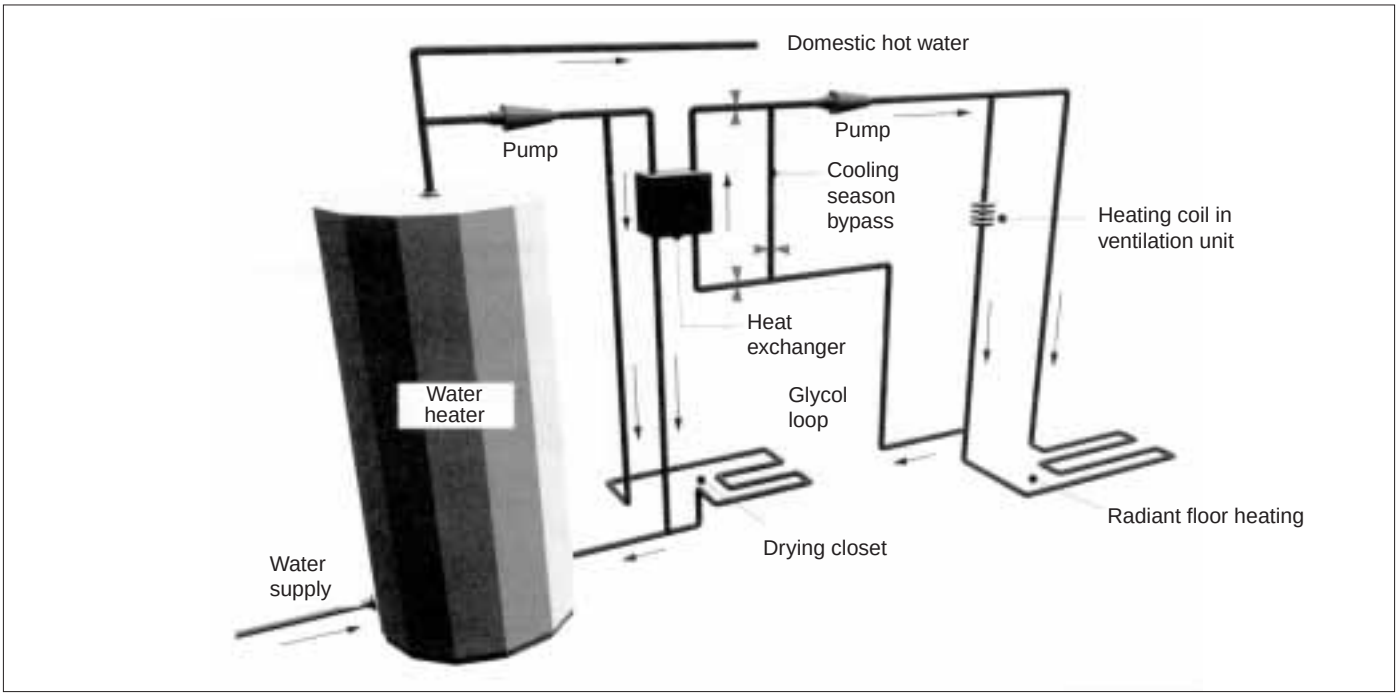

Figure 10 : Heating System

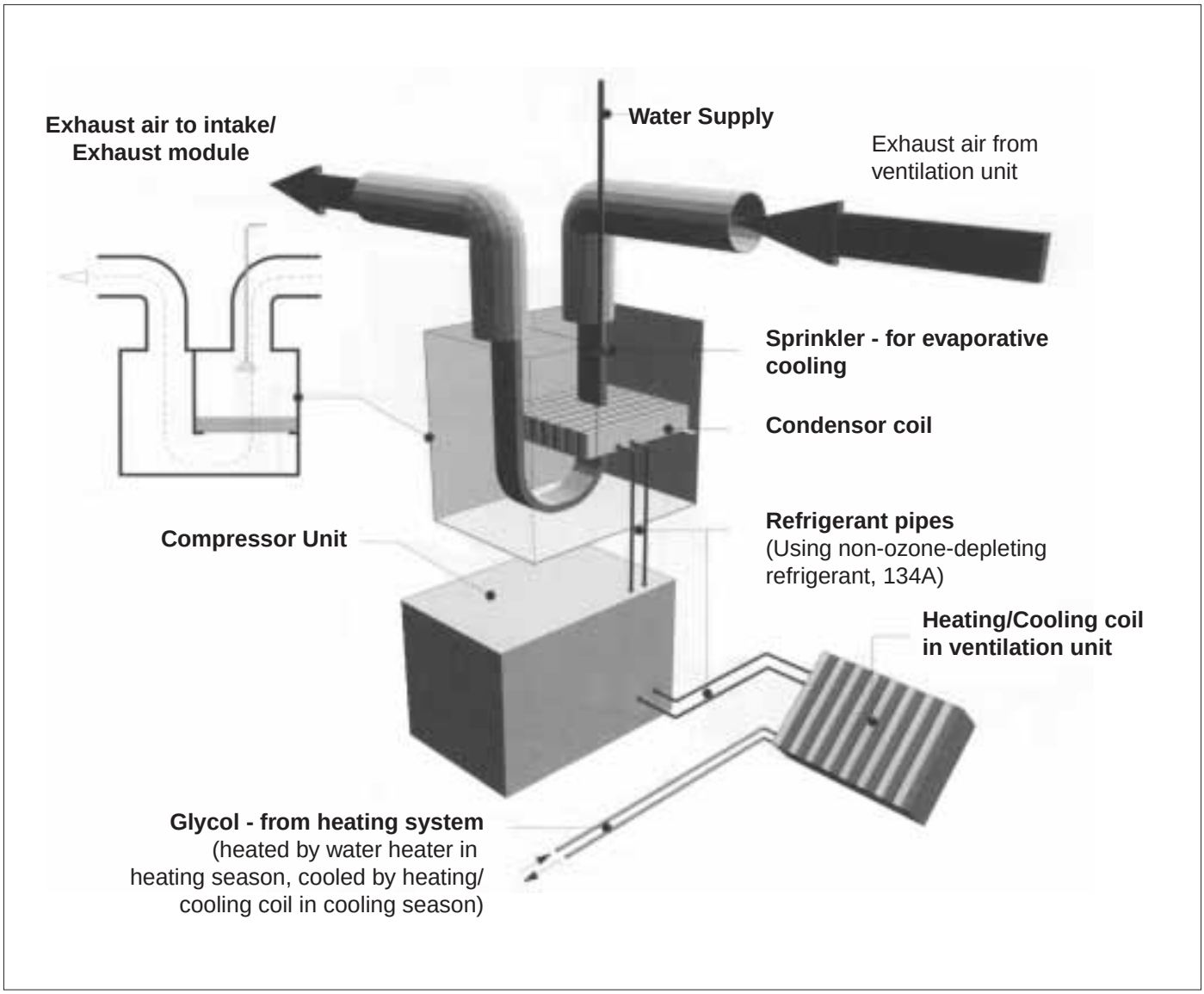

Figure 11 : Cooling/Dehumidification System

This **Research House For the Environmentally Hypersensitive** walks you through an innovative model home where the air is free of dust, mold, pollen and chemical vapours.

Designed to demonstrate affordable ways of achieving clean-air housing, this home and its features are for people with respiratory problems and environmental hypersensitivities or anyone concerned about the air quality in their home.

Check out the details that make this house a healthy haven and prototype of the house of the future.

For builders, renovators and homeowners—it's like a breath of fresh air!

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