Remote And Northern Energy-efficient House Design Catelogue
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REMOTE AND NORTHERN ENERGY-EFFICIENT HOUSE DESIGN CATALOGUE

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PREPARED BY:
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Executive Summary

Current problems facing those who design, build and live in housing in remote and northern areas in Canada include: high heating and related operating and maintenance costs; uncomfortable – and at times unacceptable – living conditions; and, poor durability and performance of the building and its components.

This catalogue of low-energy house designs will serve as a useful tool for housing managers, builders, and government agencies involved in remote and northern housing.

The work was carried out in two parallel streams: one dealt with assembling the latest information on building science issues affecting housing in the north, primarily from secondary (print) sources; the other dealt with directly contacting those people in the field with first hand knowledge and experience about the design, construction and operation of houses in northern areas.

On the basis of these contacts, a series of 15 new house case studies and 5 retrofit case studies have been assembled, documenting what works – and what doesn't – in remote and northern contexts.

Part One of the catalogue acts as a primer on northern housing design and construction issues. It documents how critically important it is to relate a building's design and construction elements to the regional and local conditions in northern and remote areas.

Typically, these conditions include: long and extremely" cold winters, with much blowing and drifting snow; poor soil conditions which can be unstable (often in association with areas of continuous and/or discontinuous permafrost); wide variation in the availability and cost of fuel and building materials (partly due to transportation problems); and, northern lifestyles and economies with a significant emphasis on hunting, trapping and fishing.

Equally important in arriving at housing designs which are appropriate in northern and remote areas is an understanding of elementary building science issues, particularly the importance of controlling the movement of air, moisture and heat flows through the building envelope. It is generally agreed that lack of control over these elements is a major factor in the accelerated deterioration and premature failure of housing in extremely cold climates.

Choosing a foundation system which will accommodate frequent, and at times unpredictable, soil movement due to freezing and thawing is also of crucial importance in ensuring longevity of housing in the north. Selecting well insulated building assemblies, including floors, walls and ceilings, which have a durable air barrier system, is the next step in realizing appropriate, low-energy houses in the north. Better quality windows and doors with higher thermal performance and more durable weathersealing and operating characteristics are important, as well.

The mechanical equipment planned for low-energy housing should be considered with several points in mind. Due to the tightness of the building envelope, more care is needed to ensure that the equipment which use air for their operation, such as woodstoves, will operate efficiently and safely.

Ventilation problems have often been acute in northern mess. Houses are either under-ventilated, causing high humidity and related moisture problems, or, the continuous running of electric fans results in high operating costs in areas of high electricity charges.

Ventilation strategies come down to two main choices in the north: mechanical ventilation, involving the operation of a fan or fans; and, passive ventilation, a relatively new and as yet unproven technique, involving the incorporation of intentional openings in the lower and upper portions of the house and relying on wind and stack effects to provide fresh air to the occupants.

Having provided the steps on how to evaluate house plans in Part One, Part Two of the catalogue documents fifteen examples of new house construction which have actually been built in the north and assesses the extent to which these designs meet northern criteria.

Each house has been assessed on the basis of energy-efficiency, durability, ease of maintainance, construction skill requirements, and occupant suitability. While none of. the houses are perfect, they are good examples of better building practices in remote and northern areas.

From the standpoint of the builder, the successful designs are those which are simple, quick to build and easy to replicate elsewhere. Preferred designs are also those that do not require a great deal of skilled labour and which can be built with one knowledgeable individual and several members of the local labour force. Builders also preferred designs with elevations which could be changed easily.

Problem areas for builders in the north include: plans in metric measurements (all building materials in the north are available only in imperial measurements, which creates confusion and considerable waste in materials and time, in what is already a very short building season); plans which are incomplete; and, a general lack of variety in plans available.

From the standpoint of the building owner or occupant, the better plans are those which: are durable (not requiring a great deal of maintenance or repair); have warm and comfortable living spaces with open layouts; have low heating requirements; and, are flexible in order to accommodate variations in preference for floorplans, window sizes and locations, and entrance locations.

From the standpoint of the owner/occupants, the better designs are those which: have an abundance of storage and work space; entrances that do not open directly into living areas; window hardware that is durable even in cold temperatures; has warm floors; and, mechanical systems, particularly the ventilation system, that are easy to understand and operate.

It is not the intent of the catalogue to be the only source of information to be used by the reader in arriving at a decision about which house design is best for a given location. Nor does the catalogue purport to have identified all the answers to some of the issues raised – ventilation being a case in point.

However, this catalogue is the first national document of its kind with a focus on northern and remote areas. It provides a thumbnail sketch of a selection of plans that are affordable, easy to build, durable and energy efficient. In addition, it introduces the reader to a systematic approach to evaluating – and making decisions about – low-energy house plans.

SOMMAIRE

Ceux qui conçoivent et construisent les habitations clans les regions éloignées du Canada de même que ceux qui les habitent font face a certains problèmes: le coût du chauffage est élevé, de même que l'entretien des appareils; les conditions de vie sent difficiles; les maisons et leurs composantes ont un rendement et une durability médiocres.

Le present catalogue se veut un outil de travail a l'intention des gestionnaires de projets d'habitations, les constructeurs et les agences gouvernementales des communautés éloignées.

La documentation est le resultat de deux démarches de recherche entreprises en même temps : l'une consistait a reassembler les information les plus recentes concernant les habitations situées clans le Nerd et les regions éloignées par le dépouillement de documents deja existants, l'autre consistait a recueillir de l'information en interrogeant directement des gens du milieu ayant des connaissances pratiques et de Inexperience de la conception, de la construction et du fonctionnement des maisons clans le Nerd.

A partir des donnés recueillies, 15 etudes de cas se rapportant a la construction de maisons neuves et 5 etudes se rapportant a des renovations ont été compilées, lesquelles démontrent bien les demarches efficaces ou non en fait de construction clans le contexte des regions éloignées et du Grand Nerd.

La premiere partie du document constitue un ouvrage élémentaire sur la construction et la planification clans le Nerd. Le texte démontre bien l'importance d'adapter la planification et la construction d'une habitation aux conditions locales et régionales.

Les conditions sent vraisemblablement les suivantes : de longs hivers extrêmement rigoureux ponctués de rafales et de poudrerie; un sol peu propice, instable (clans des zones de pergélisol ou de dégel périodique): les coûts associés a l'énergie et la disponibilité des matériaux de construction varient énormément (a cause des problèmes -relies au transport en partie); un style de vie ainsi qu'une économie qui repose en grande partie sur la chasse, le trappage et la pêche.

Si l'on veut arriver a concevoir des modèles de maisons appropriees pour le nerd et les regions éloignées, il importe de posseder des notions élémentaires de construction, particulièrement pour ce qui a trait au contrôle de la circulation de l'air, de l'humidité et de la chaleur a l'intérieur de la structure. En general, on sait qu'une mauvaise maîtrise de ces aspects contribue a accélérer la deterioration des habitations situées clans des regions où règne un froid intense et a les rendre inutilisables.

Pour assurer la durability d'une maison clans le Nerd, il faut d'abord choisir un systeme de fondation apte a resister a l'instability du sol, provenant du gel et du dégel. Lorsqu'il est question de maisons efficaces sur le plan énergétique, appropriees pour les regions nordiques, il faut alors penser que les composantes de construction, c'est-a-dire le plancher, les murs et les plafonds, doivent être munies d'un coupe-vapeur et d'un isolant durables. Il faut aussi tenir compte de la qualité des fenêtres et des portes qui doivent être dotees d'une meilleure étanchéité et de bonnes caracteristiques de fonctionnement.

Les appareils mecaniques qui fonctionnent clans une maison a haut rendement énergétique exigent une attention toute speciale. Compte tenu de l'herméticité de ce genre de construction, on doit prendre garde d'éviter les risques généralement associés a l'usage d'appareils a combustion a air en milieu fermé.

Dans les regions nordiques, les maisons a problèmes de ventilation sent chose courante. Les maisons sent parfois mal ventilées, ce qui occasionne des taux élevés d'humidité et autres problèmes, ou encore munies de ventilateurs électriques qui fonctionnent tout le temps a pleine capacite clans une region où justement l'electricity coûte plus cher.

Pour ce qui est de la ventilation, deux possibilities s'imposent : la ventilation mécanique, qui implique l'utilisation d'un ou de plusieurs ventilateurs, et la ventilation a systeme passif, une technique relativement nouvelle qui n'a pas encore fait ses preuves, qui implique des overtures ménagées clans les cloisons extérieures de la maison (en bas d'un côté, en haut de l'autre). Cette dernière méthode depend des vents et des courants d'air pour fournir l'air frais aux occupants.

INTRODUCTION

A combination of high energy costs and deteriorating housing stock has highlighted the need for energy-efficient housing in Canada's northern and remote communities.

For housing to be successful in these severe climates, it must address a number of competing needs. It must be affordable – both to build and to operate. It must be durable – providing comfort and allowing easy maintenance. It must be capable of meeting the needs of the individual families in their specific region of the country. Above all, the building must be energy-efficient – a home which provides exceptional comfort, and uses only half of the energy of conventional housing. The homes featured in this catalogue have been selected as examples of buildings that work well in severe climates.

This catalogue documents the design and construction of energy-efficient housing in Canada's northern and remote regions. We recognize that no one house will be appropriate for every region – and that you may want to consider other designs and construction practices more suited to your personal needs. To assist you in choosing a design suited to your requirements, *Part One* of the catalogue provides guidance on how to evaluate a set of plans. We detail what you should be looking for in the plans and how the plans can be altered to your satisfaction. And we've assembled a primer of building science principles so that you can make sure that any design is suited to your region of the country.

The catalogue isn't just based on theory. We've talked to the people who designed, built and live in the houses to hear their assessment of the houses. We've recorded both the good and the bad comments. Their first hand experience provides an insight lacking from an analysis of a set of floor plans and construction details.

Part Two of the catalogue offers the reader a variety of energy-efficient house designs and construction techniques suited to remote and northern Canada. It will serve as a useful tool for housing managers, builders, and government agencies involved in remote and northern housing. More important, it will allow homeowners the opportunity to evaluate and decide upon the design, floor plan and construction techniques which will provide them with a durable, comfortable and energy-efficient home.

PART ONE THE PRIMER

The first section of this Catalogue is a primer of construction and design principles related to remote and northern housing. This primer is intended to assist the reader to assess the designs contained in this catalogue, and others, for their appropriateness to a specific site. Throughout the primer, common problems experienced in the construction and operation of new housing are highlighted. The primer provides the reader with an understanding of the critical elements of construction details and practices, allowing you to address these problems.

The primer is divided into four parts:

Section one: Energy-Efficient Housing: Regional and Local Considerations
In this section we analyse the factors that set remote and northern housing apart. The section provides an overview of the design requirements of an energy -efficent house.

Section two: Planning the Energy-Efficient House
This section evaluates the requirements of design and construction details suited to severe climates. The successful design will control the basic flows of heat, air and vapour through the shell of the building.

Section three: Choosing Mechanical equipment
Increased insulation and tighter construction practices place different demands on the house's mechanical systems. This section of the primer examines heating and ventilation system options for energy -efficent housing in severe climates.

Section four: Retrofit
Improving the energy-efficiency of new housing is one step in the right direction. At the same time older buildings can be made more energy-efficient. This section of the primer describes different options for improving the energy -efficency of existing homes.

1.0 ENERGY-EFFICIENT HOUSING: REGIONAL AND LOCAL CONSIDERATIONS

To decide which design features are suitable for a specific site really means answering a number of questions. For example: Does this wall hold enough insulation? Are there enough windows on the south-facing side of the house? Is this furnace too big? Too small? To answer these questions requires an understanding of a number of regional and local factors. These factors range from climate and weather to lifestyle, and combine to affect the cost and performance of the house. Any house design can and should be altered to reflect these factors.

1.1 Climate and Weather

Climate and weather are possibly the most important elements to consider when choosing low-energy design features. Climate can be defined as the average total of rain and snow and wind and sun an area is likely to receive over a period of time; weather is how much of those things you receive on any given day. If climate is what you expect, weather is what you get.

Together climate and weather will affect almost every part of house design. For example, in colder climates you will need more insulation in the roof and walls. Windier climates need a more weatherproof shell. The amount of rain will affect the foundation drainage system. The amount of snow will affect the roof system. Harsh weather will also affect the type of materials used in constructing the building.

Climate and weather can have other, less obvious effects. The transport of workers and materials to the job site is often dependent on seasonal transportation routes. The length of the building season itself depends greatly on the weather and will affect the size and complexity of the building. Frost-free periods and dates of freeze-up and break-up will determine the best times for building operations.

Design Considerations

- The colder the temperature, the greater the heat loss. The wall and roof system detailed in the plans should allow for high levels of insulation. *

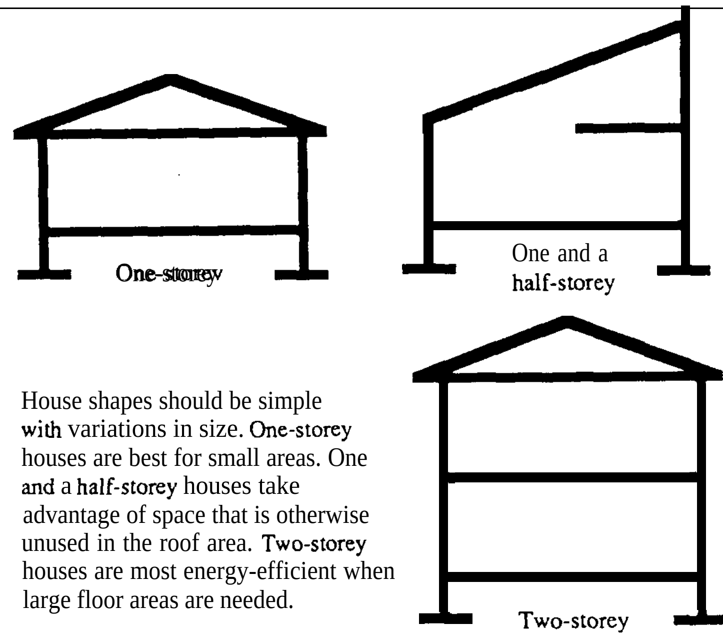
- Make sure that the majority of windows are on the south side of the house. This will add to the amount of sunshine entering the house and help with the heating requirements.

- The direction and strength of the wind will have an effect on building shape and site planning. Keep the building shape simple with few projections to reduce wind forces on the surface of the building.

  In addition, placing the house parallel to the prevailing winds will help minimize the effects of snow drifting.

- The length of the construction season will affect the type of house you can build. A short construction season demands that the design be simple, quick o build and close-in.

- Roofs must be designed to withstand loca wind and snowloads.



House shapes should be simple with variations in size. One-storey houses are best for small areas. One and a half-storey houses take advantage of space that is otherwise unused in the roof area. Two-storey houses are most energy-efficient when large floor areas are needed.

** While there are no hard andfast rules about temperature and insulation, RSI 5.0 (R28) should be considered an absolute minimum in all above-grade assemblies.*

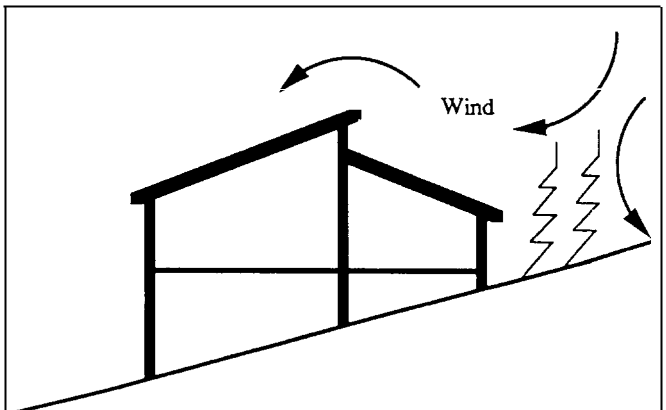
1.2 Soils and Landscape

Soils, vegetation, and the natural landscape can also have a major influence on house design and construction. Decisions on site selection, the direction the house faces, and the type of foundation system should be made with these things in mind.

Soil conditions throughout the country may include muskeg, gravel, and clay. Different soil conditions will require different foundation 'solutions'. Areas of permafrost or discontinuous permafrost are particularly challenging and will require careful consideration. A foundation that does not suit the site conditions can shift, causing serious damage to the rest of the house.

Vegetation, such as trees, can act as windblocks and reduce the effects of snow drifting, and should be used to advantage when selecting a site. Natural land forms, such as southern slopes, can help increase the amount of sunshine entering the house, and help to reduce the heating load.

In barren areas, or areas of tundra, winds and snow will have free rein. Site selection, orientation, and building shape become even more important in these areas. In particular, the building should be compact to minimize exposed surfaces, and ease construction.



Protection from Prevailing Winds

Design Considerations

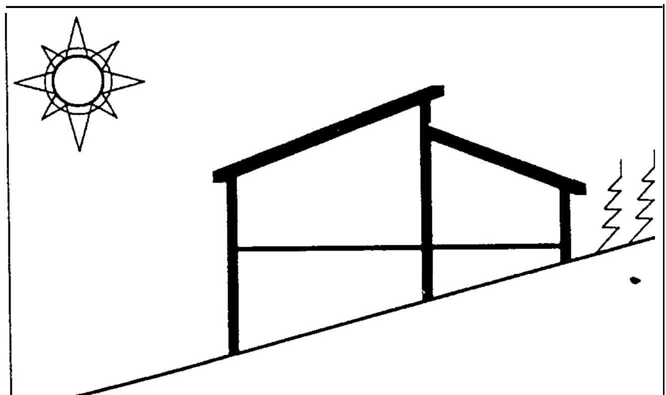
- Soil tests are a must. This is especially true in areas of discontinuous permafrost where soil conditions can vary from site to site within the same community.

- Choose sites that have the best drainage. This will reduce the chance of moisture damage to the foundation.

- Site preparation in permafrost areas – construction of a gravel pad for example – may extend over two years to allow for settling and drainage.

- Site selection should consider natural land forms such as trees or southern slopes. These can be used to provide wind breaks or to take advantage of heat energy from the sun.

- The foundation must suit the site conditions. In almost all cases, use foundations that can be adjusted to prevent damage from movement. Some suggestions about types of foundations for various soil conditions can be found in Appendix B.



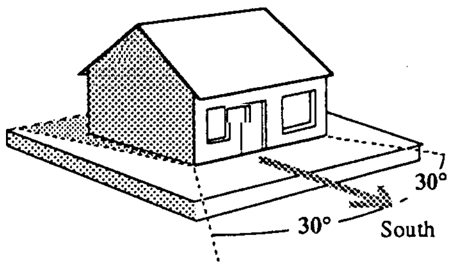
Best Orientation on South Facing Slope

1.3 Energy from the Sun

Few northern and remote areas receive enough sunshine to contribute much space heating during November, December, and January. However, many areas receive enough sunlight for heating and day-lighting in the spring and fall. Since there is still a need for space heating in both of these seasons, the design should take advantage of the sun.

Design Considerations

- An energy-efficient house with better insulated walls and an air and vapour barrier will need less heat and can make more use of free heat from the sun.



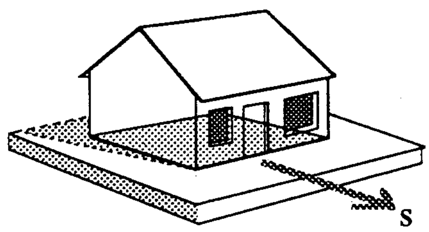
House Orientation

- It is very important to place most of the windows on the side of the building that faces south. At the same time reduce the number of windows on the north side, which are heat losers.

- Use an open plan, one with few partition walls in the living areas to allow heat to circulate naturally. An open plan means that the sunlight penetrates deeper into the building.

- Choose a site where the south windows will not be shaded in the winter.

  In lower latitides, overheating may become a problem in the summer. To prevent this provide wide eaves over south-facing windows to limit the amount of summer sun entering the house. In addition, avoid too many windows on the west side of the house, which are difficult to shade.



Window area should be no more than ten per cent of floor area or overheating may result.

South Facing Glass

- High-performance windows make a big difference in northern regions with severe climates and high fuel bills. Look for wood frames, and double or triple sealed units. New windows with 1 or 2 soft low-E coatings and an argon gas fill should be considered.

1.4 Fuel Availability and Cost

The cost-effectiveness of any low-energy design depends in large part on the cost and availability of heating fuel. While energy costs in remote and northern areas can vary considerably, nowhere can they be considered cheap. The best response to the high price of fuel is to reduce the need for it, and to use locally available sources where possible.

To reduce heating costs, the building envelope (foundation, walls, and roof), and the heating system, should be energy-efficient. With proper attention to care and detail, a well constructed, energy-efficient house can easily be heated using one-half to two-thirds less energy than a conventionally built house of similar size.

Design Considerations

- The house design should call for high levels of insulation in the foundation, walls, and attic.
- There must be an air-barrier to help keep the heat in.
- Windows and doors should be as energy-efficient as budgets allow.
- Use cold porches and air lock entries to reduce the amount of heated air that escapes when doors to the outside are opened and closed.
- Use local fuels, such as dry wood, in your certified heating equipment whenever possible.
- The type of fuel to be used will dictate certain design elements. For example, if the house is to be heated with wood you must provide a place to store the wood near the stove – and an easy way, such as a wood chute, to get the wood inside the house.
- A low-energy house means lower heating loads. Make sure that the furnace has not been oversized.

1.5 Materials Availability, Cost, and Transportation

Materials should be chosen to suit local conditions and preferences. The final selection of materials will also depenal on performance and availability.

Because of the seasonal dependence of shipping, not all materials are readily available. Preplanning is essential to make sure that the proper materials reach the job site at the right time.

The distance, weight, and size of the material will determine the most cost-efficient method of transportation. Shipping by water or road should be given preference. Water transportation has the lowest shipping costs. In addition, ships and trucks have the ability to carry items of almost any shape or size.

Shipment by air is the most expensive on a weight basis and should be avoided where possible.

An additional consideration in the choice of design and materials is how the construction process affects the local community. If a project uses building crews from 'outside', a design that saves on labour costs will be more attractive. In this case it may be cheaper to use pre-finished materials and pre-fabricated components that require less labour, even if they are more expensive.

On the other hand, if part of the project's intent is to use local labour as a means of providing an opportunity for skills training, the emphasis might be on labour-intensive construction using local materials.

Design Considerations

- One of the most important factors in northern construction is quality workmanship.

  Because of the short construction season, and because crews can sometimes be inexperienced, the best designs are those that are quick and easy to erect.

- Coordinate transportation with the construction season. In some cases, it may be necessary to ship materials a year before construction is to begin.

- While it is not always possible, site preparation should be done before the materials arrive. For example, a gravel pad should be prepared at least a year before hand to allow for proper compaction and settlement.

- Use local materials where possible. Components that can be repaired or replaced using local skills and materials should be given preference.

1.6 Lifestyle and Layout

A house must do more than simply keep out bad weather. It must also provide a warm, comfortable place to live. What is meant by ‘comfort’, however, can vary from community to community and even from family to family. One example would be the greater storage space a household in an isolated community that is serviced once or twice a year needs, compared to a household in an urban centre where there is direct access to goods and services. Another is the need for work space in households that rely on traditional income activities compared to a households involved primarily in a wage economy.

In short, a house must respond to the ‘lifestyle’ needs of the occupants.

For a number of reasons northern and remote housing has typically been small, lacking in storage space, and overcrowded. In addition, water supply and waste disposal have been problematic.

None of these are problems without solutions. A low-energy house is by nature warmer and more comfortable. With proper regard to design and layout, even a small house can seem spacious.

The most successful of the houses in the case studies were designed with input from the clients. Even where this is not possible, houses can be designed to be flexible, with interior partitions that can be moved or shifted to create a larger space or additional space.

Design Considerations

One of the first things to make sure of when looking at a design is that the basic area requirements are there. These include:

- living areas (kitchen, dining, and living rooms),
- a sufficient number of sleeping areas for the size of the family,
- special areas (mechanical, utility, and work rooms),
- storage space, and
- two entrances/exits.

While the ideal layout may vary from family to family, there are some general rules of thumb that should be kept in mind when examining a set of plans.

- Design the floor plans with few partition walls in the living areas to give a feeling of ‘space’ and assist heat distribution from a central stove or furnace. Grouping the kitchen, dining and living spaces together creates an area that can be used for a wide range of activities. These living areas should be on the south side of the house, where they receive the most sunlight.

- Put rooms that require fewer windows, such as utility rooms and bathrooms, on the north side of the house.

- To reduce noise from mechanical equipment, put water tanks, hot water heaters, pumps, furnaces, etc., in a separate room, isolated from the living space.

- Storage and work (utility) spaces should meet the needs of the family.

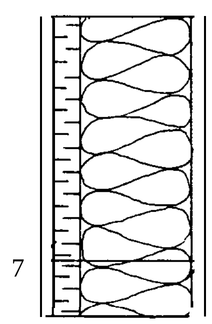
2.0 PLANNING THE ENERGY-EFFICIENT HOUSE

A low-energy house uses less heating fuel than a conventional house – and is more comfortable and more durable. To do this it must keep the heat in and the cold out better than other houses. Low-energy houses are designed to better control the flows of heat, air and moisture through the house shell or envelope. Low-energy house design recognizes that all aspects of a house are interconnected – the house envelope, the mechanical systems and the occupants.

An understanding of the relationship between these factors is central to a successful design. For example, a house with a great deal of insulation will be better served by a smaller than normal heating system. Similarly, a 'tighter' house has the benefit of being less drafty, but the potential concentration of moisture in the house demands that a fresh air supply be considered.

Before looking at how an energy-efficient house is actually built, we will look at how heat, air, and moisture travel through the house, and how the construction of the house controls these flows.

2.1 Building Basics



	RSI	R
Drywall	0.08	0.45
Fibreglass batt (89 mm)	1.80	12.0
Rigid insulation (38 mm)	1.33	7.5
Siding	0.14	0.81
To[al	3.35	20.76

Resistance Through a Wall Section

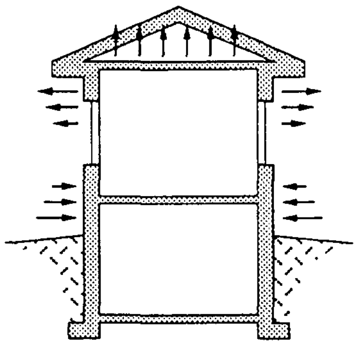
Heat Flow

Heat flows from warm areas to cold areas. The greater the temperature difference between inside and outside, the greater the potential heat loss from the home.

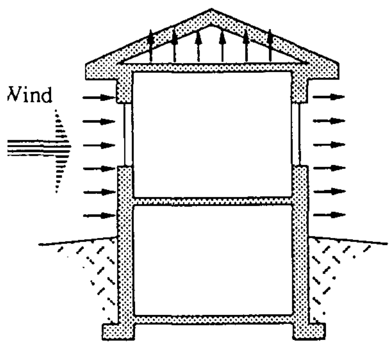
Controlling Heat Flow

Insulation materials slow the flow of heat through the building envelope; the materials are rated by their resistance to heat flows – commonly referred to as the RSI value*. The higher the RSI value, the greater the material's ability to slow down heat flow. The colder the climate, the greater the need for, and benefits from, installing high RSI levels of insulation.

* *RSI is a metric term. As an imperial measurement it is expressed as an R value. See the Appenix for the way to convert metric values to imperial or imperial to metric.*



Stack Effect



Wind Effect

Air Flow

Controlling the air that flows through the building shell is a cornerstone of low-energy design. Air flows must be controlled for two reasons.

- Heat is carried out by air escaping from the house.
- Escaping air carries moisture into the walls and attic where it can cause damage.

Under winter conditions the temperature difference between indoors and outdoors creates a difference in air pressure between the inside and the outside of the house. This causes warm air to escape through the upper parts of the house (stack effect). Cold air seeps in around floors and baseboards to replace the escaping warm air.

Wind also affects air flow through the house, forcing cold air in through cracks and holes on the windward side and pushing warm air out on the opposite side. These cold drafts are uncomfortable and heating the cold air that leaks into a drafty house requires a lot of energy.

Controlling Air Flow

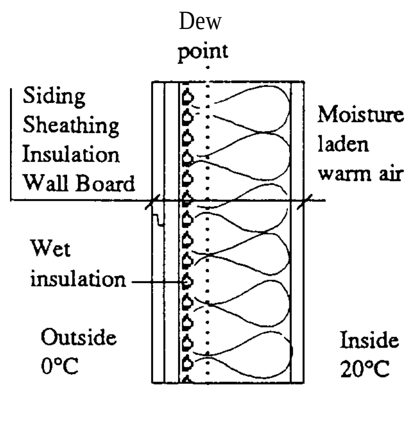
Controlling air flow involves two steps:

- making the building shell 'tighter' to stop uncontrolled air leakage, and
- supplying fresh air for ventilation and combustion . purposes - when and where it's wanted.

Low-energy houses are 'tighter' houses. An air barrier is installed to control air leakage through the building shell. The air barrier also makes the house more durable by preventing building damage that is caused when moisture in the escaping house air condenses in the walls or attic. For a complete discussion of air barriers, refer to section 2.2.

Stoves, furnaces and heaters that burn fuel need a lot of air for combustion and to keep a good draft in the chimney. A separate air supply must be provided; otherwise stoves and furnaces will cause more cold air to be drawn into the house. Similarly, the operation of exhaust fans will cause cold outside air to be drawn into the home.

Moisture Flow



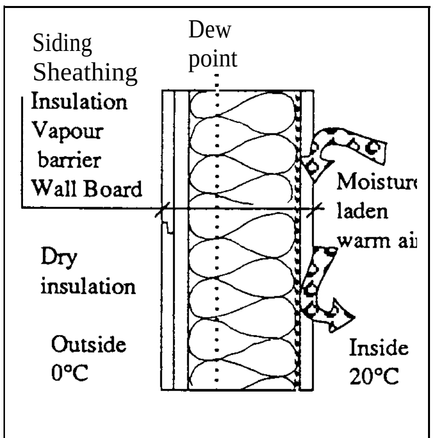
Wall Without Vapour Barrier

Most building damage is caused by moisture: as solid ice, as liquid water, or as water vapour. This section discusses the control of water vapour that comes from inside the house. Controlling rain and snow is described below.

House air holds a lot of moisture. Water vapour is produced inside the home by cooking, washing and drying clothes, bathing, and other activities. When the water vapour contacts a cold surface it condenses, leaving liquid water inside the walls, on windows, or in the attic. Under certain conditions the result is rotting wood or poorly performing insulation.

Water vapour can move from inside to outside in two ways: it can be carried by air that is leaking through holes in the building shell or it can move directly through materials by a process called *diffusion.*

Controlling Moisture Flow



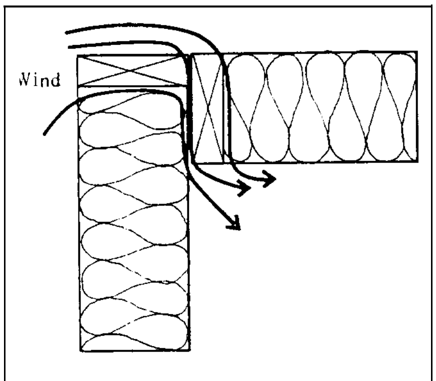
Wall With Vapour Barrier

You can control water vapour in several ways. The first line of defense is to reduce the amount of moisture generated, e.g., by putting lids on cooking pots or not drying wood or clothes indoors. A second strategy involves removing the moisture from the house – with an exhaust fan.

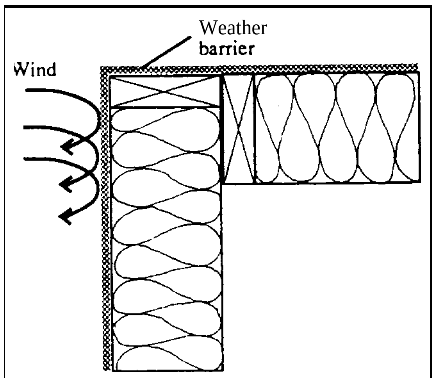
Diffusion can be controlled by installing a vapour barrier – a material which resists the flow of water vapour. Polyethylene, foil, plywood and some paints all serve as effective vapour barriers. The vapour barrier should be installed on the warm side of the insulation (to stop the water vapour before it can cool and condense).

However, far more water vapour is carried out of a house by air leakage than by diffusion. While a vapour barrier will not prevent water vapour from escaping through air leakage, an air barrier will. This makes the air barrier doubly important; not only does it prevent cold drafts and heat loss, it also prevents moisture damage to the building shell. This aspect is especially important in the north, where extreme temperatures can result in serious moisture damage if water vapour movement is not controlled.

Some materials such as polyethylene or exterior grade plywood are resistant to the movement of both air and water vapour and can serve as both air barrier and vapour barrier.



Wall Wi/bout a Weather Barrier



Wall With a Weather Barrier

***Exterior** Weather and Moisture Protection*

A weather barrier underneath the siding will prevent wind, driving rain or snow from getting inside the wall. At the same time it should allow any moisture in the wall to evaporate to the outside. The barrier also stops cold air from blowing through the insulation and improves insulation performance.

Because of the harsher temperatures in remote and northern communities, the weather barrier must be made of a material that will not shrink or shatter: plywood, tentest, or foam sheathings may therefore be more suitable than sheet materials.

Exterior weather and moisture protection also includes:

- dampproofing,
- drain tile that directs groundwater away from the foundation,
- skirting that offers wind protection around open crawl spaces, and
- gutters and downspouts that direct rainwater away from the walls and foundation of the house.

2.2 Air Barrier Systems

The difference between the air barrier and the vapour barrier may seem confusing at first, but it isn't really very complex. The major difference between air barriers and vapour barriers is that air barriers should be continuous, and sealed; vapour barriers do not have to be. Also, vapour barriers must be on the warm side of the insulation; air barriers do not have to be. While air barriers and vapour barriers can be made of different materials, and be installed in different locations within the building envelope, the most common approach is to combine them using one material, such as polyethylene.

Air barriers play a critical role in low-energy construction. They make the house more comfortable by reducing cold drafts and they cut down on heat loss from air leakage. Air barriers also make the house more durable by preventing water vapour from condensing within the walls or attic.

Common Problems

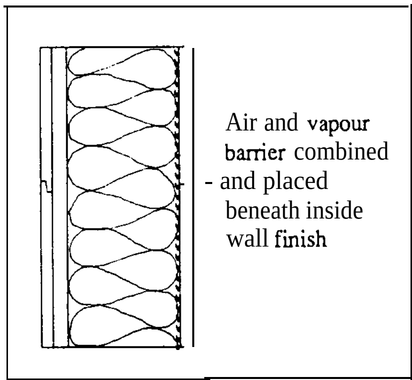
The air barrier is broken by the doors, windows and service openings. Northern and remote housing has features which make it even harder to install and maintain an air barrier.

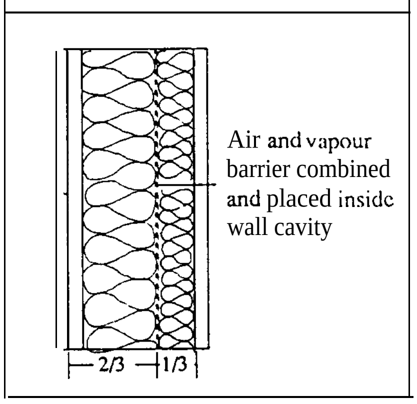
- *Northern houses often include additional penetrations for water fill and overflow pipes, wood chutes and air locks.*
- *A poor foundation in permafrost conditions can lead to uneven settlement, which can break seams, caulking seals or gaskets in the air barrier system.*
- *Caulking and weatherstripping materials may not be easily available, which can make it difficult to install and maintain the air barrier properly.*

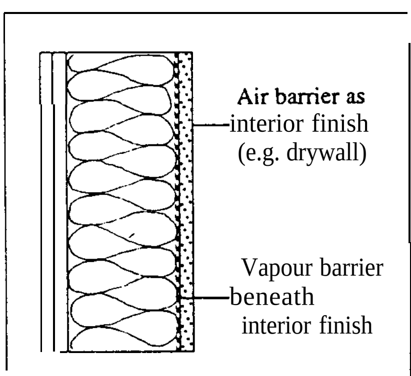
The air barrier system will affect the house whether the job is done poorly or well.

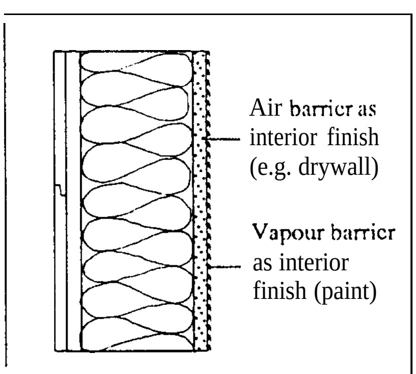
- *An air barrier that is not continuous or durable means a less comfortable, drafty house that is more costly to heat. It is also more likely that the house will suffer moisture damage.*
- *On the other hand, if the house is well sealed there must be a way to bring in a controlled supply of fresh air for ventilation and combustion . If this is not done the occupants' health and safety could be affected.*

Design Considerations









The air barrier system should be continuous, resist air movement, withstand air pressure differences and be durable. The plans should provide details for sealing penetrations. Here are some additional details to look for when evaluating an air barrier system.

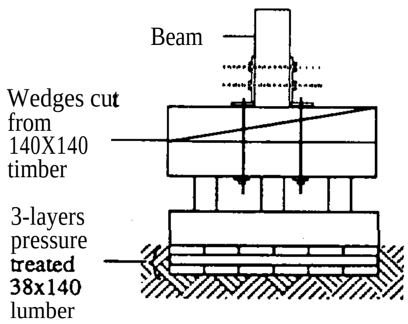
- Include weatherstripping and latches to provide a positive, compression seal at hatches, windows and doors.
- Seams in sheet material should be lapped, caulked and stapled over a solid backing.
- Install sheet material with enough slack to allow for shrinkage due to cold.
- Recess the air barrier in the wall to allow for an electrical and plumbing chase or provide details for sealing electrical and plumbing penetrations; or surface mount electrical.
- Seal all attic penetrations – i.e. plumbing stack and chimney. Use heat-resistant materials around the chimney.
- Make sure the air barrier materials are able to last as long as the house.
- For houses with open crawlspaces, provide an air barrier for the floor assembly and seal it to the wall air barrier. Make sure the subfloor is glued down or caulked to make it airtight, then seal the wall to the floor.

  Also provide a continuous weather barrier on the underside of the floor joist. Otherwise the wind will blow through the insulation and make the floor icy cold.

2.3 *Foundations*

Foundation design and attention to construction detailing are extremely important. In many instances, remote and northern communities must build on unsettled soils, expansive clays and, even more likely, permafrost conditions. It is essential when considering a set of house plans to be knowledgeable about the specific soil conditions on the building site.

While foundation types are somewhat interchangeable – you might use the foundation details from one plan as an alternative to the plan you choose – great care must be taken in considering all of the other changes to the plan. Dimensioning, material changes and even structural considerations may be affected. Any major changes to a set of drawings should be approved by a professional.



Pad and Wedge Foundation

Foundation design for permafrost and discontinuous permafrost conditions is an ongoing concern. The most commonly used systems employ pads and wedges located on a gravel base. While this often represents the least expensive approach, it requires seasonal maintenance to ensure that the house remains level. Point support systems employing piers or piles are more expensive but, when properly constructed, these systems represent a more permanent solution. The space frame foundation featured in the Hay River case study represents a new and promising approach to permafrost foundations. (See also Appendix B – Foundations.)

Common Problems

- *Uneven settling of the building caused by soil movement.*
- *Undermining of the footings caused by poor drainage,*
- *Cracks in foundation walls caused by poor quality materials and workmanship.*
- *Condensation / rotting in unventilated crawl spaces,*
- *cold floors resulting from insufficient insulation and poor detailing of the weather barrier.*
- *Noisy floors resulting from excessive shrinkage and poor connection of the subfloor to the floor joists.*

*What to Look for On a Set of **Plans***

A good set of working drawings will give you an understanding of how the foundation will be built and how it will perform. The plans should include:

- Footing details and specific requirements for site soil variations.
- Specifics on the materials which may not be locally available (preserved wood, metal framing connectors, etc).
- Specific details on moisture protection – types of materials, site drainage, dampproofing, etc.
- Details on insulating and weatherproofing crawl spaces, floors over unheated spaces and full foundation walls .

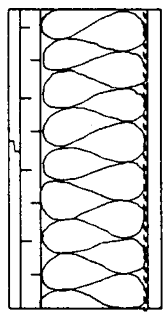
Design Considerations

- Foundations cannot be easily repaired and/or replaced! Make sure that the foundation is designed to outlast all other components of the house.
- Foundations in difficult soil conditions must allow for levelling in the event of building settling.
- Effective drainage of the area surrounding the foundation is essential. Most damage occurs from the freeze-thaw cycles attributed to wet soils.
- For floors over unheated spaces, use similar insulation levels to those in the walls and include a vapour barrier on the interior and a weather barrier to prevent cold winds from blowing into the floor assemblies.
- Use clear-span joists to help to limit differential settlement.

2.4 *Above-Grade Walls*

The above-grade walls of the building often represent a major part of the exposed surface of the building — and can be one of the major sources of heat loss. Any plan under consideration for remote and northern communities must include high levels of insulation and a system for controlling air and moisture movement.

There is a wide range of wall systems which builders and designers have used. In most cases the wall designs provided in the case studies of this catalogue are interchangeable. The plans you are looking at might describe one approach, but you can alter the design if you think another wall system would work better.



The most common practice for northern and remote housing is based around 2x6 wood frame construction, allowing for RSI 3.52 (R20) insulation levels using glass fibre insulation. Additional insulation can – and should – be added to this wall design without a large change to the plans. And you can easily add exterior insulating sheathing under the siding, or interior cross strapping. The major alterations to consider include detailing around windows and doors of a wider wall, and different installation requirements for siding and/or interior wallboard.

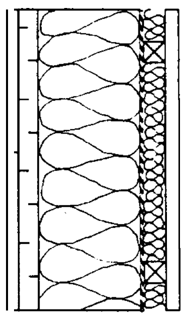
Common Problems

- *Inadequate levels of insulation leading to higher than necessary fuel costs.*
- *Moisture damage to the interior surfaces resulting from condensation on cold interior surfaces.*
- *Poor air barrier installation resulting in cold drafts and high fuel bills.*
- *Moisture damage to the envelope resulting from poor air and vapour barrier treatment.*
- *Moisture darnage to the envelope resulting from inadequate weather protection against rain and snow.*
- *Structural movement resulting from inadequate cross bracing.*

What to Look for On a Set of Plans

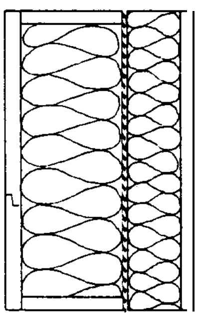
A good set of working drawings will allow you an understanding of how the wall system will be built and how it will perform. The plans should include:

- A detailed cross section, identifying all of the components of the house walls.
- Framing diagrams: plans and elevations showing all framing members are useful; essential if the house is to be built by unexperienced people, or if all the components are shipped in.
- Details showing the treatment of penetrations in the walls – air barrier detailing around electrical outlets, windows and doors – to ensure better long-term performance.
- Framing details outlining the process to be followed. This is especially important when the house is to be built using inexperienced labour.



Design Considerations

- Walls generally represent the largest single component of the building shell, and should have as large a thermal resistance as practically and economically possible.
- If replacing structural sheathing with insulated sheathing, cross bracing must be installed.
- The design must provide for adequate protection against wind, rain and snow penetration.
- In regions with high winds it may be worth eliminating unnecessary penetrations in exterior walls (electrical, plumbing, etc.), by moving them to intenor walls and/or floors. In high wind areas the air barrier should be supported on both sides; polyethylene, for example, could be installed between two layers of wallboard.
- Where interiors are prone to damage, double layers of drywall or plywood sheathing may prove more durable.
- Fire resistance ratings equal to those required in the National Building Code are necessary; be especially careful in areas close to woodstoves or other heat sources.



2.5 Roofs and Attics

Specific house plans should be assessed from the perspective of the design and recommended construction techniques for building roofs and attics. You should look at the ability of the roof to withstand snow loads in your specific region as well as the means by which the design allows for high levels of insulation and airtightness.

Colder climates can place additional levels of complexity onto the design and construction of house roofs and attics. The most common roof design involves a ventilated attic – allowing outside air to flow into the attic, removing moisture to the outside. While this may prove effective in warmer regions of the country, open ventilation spaces in the far north provide an easy access into the attic for wind driven snow.

Unventilated roof designs are still the source of some debate. If considering a design which doesn't provide for ventilation, you must be sure to prevent the flow of house moisture into the insulated areas. Both an effective air barrier and a vapour barrier must be shown in the plans. While still in the developmental stages, it appears that unventilated roofs hold a great deal of promise for northern housing. (Note: permission must be obtained from code authorities to build an unventilated roof).

From a construction perspective, the use of prefabricated roof trusses will prove to be a major time saver. Trusses are available in many of Canada's northern communities, although high freight charges make their use in remote areas more limited.

Common Problems

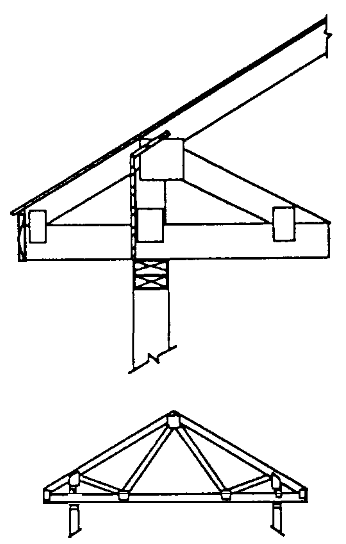
- *Moisture darnage caused by house moisture leaking into attic cavities, where it condenses and causes rot.*
- *Moisture damage caused by water backing up under the shingles because of ice damming at the eaves.*
- *Moisture in the attic caused by the build-up of wind-driven snow entering through ventilating soffits.*
- *Truss uplift – where drywall joints between partition walls and ceilings separate. This phenomenon is attributable to moist trusses and differential temperatures between the upper and lower chords of a truss.*
- *Uneven ceiling surfaces, caused by poor framing practices.*

What to Look for On a Set of Plans

A good set of working drawings will allow you an understanding of how the roof system will be built. The plans should include:

- A detailed cross section, identifying the roof components, and ventilation strategies.
- Framing details outlining the process to be followed through construction.
- Details showing the treatment at the eaves to prevent ice damming.
- Details showing the treatment of any penetrations into the attic and through the roof sheathing.

Design Considerations



High-Heel Truss

- Consider an exterior attic hatch. An interior attic hatch is just one more hole in the air-vapour barrier that can be difficult to seal effectively.
- Make sure the insulation levels reflect the climate you are living in – the colder the climate, the more insulation you should consider.
- The design must provide for adequate protection against wind, rain and snow penetration – seasonally adjusting cave venting may be an alternative.
- A continuous air barrier across the roof area is fundamental to the roof performance. The air barrier should be maintained through partition walls.
- Penetrations through the ceiling to the attic should be carefully and permanently sealed. Gasketing around plumbing stack penetrations and air barrier boxes around electrical fixtures are time-saving alternatives.
- Use fire resistance ratings equal to those required in the National Building Code; ensure proper installation of flues running through the attic areas.

2.6 Doors and Windows

Windows play a unique role in the home. Correctly sized (window area should be no more than ten per cent of floor area), oriented (south facing), and constructed, their heat gains can outweigh their heat losses.

Unfortunately, most windows are simply not built for the harsh weather conditions encountered in many remote and northern areas. Broken weatherstripping and hardware leave windows even leakier and subject to the damaging effects of condensation.

Cheap windows will not save you money in the long run. A good window will pay you back the additional cost by helping keep heat in the house. If you are heating with any fuel other than wood it pays to buy high-performance windows. At a minimum, plans should call for double-glazed windows with a 12 mm (1/2”) sealed unit.

Doors also suffer from the effects of harsh weather and extensive use, and become big heat losers. Avoid light-weight frames. Doors should be steel, with an insulated core – and have heavy duty hardware.

The number, placement, and type of door can also affect the heating load of the house, as well as occupant comfort. Doors should be out of the path of prevailing winter winds; either placing them on the leeward side of the house, or provide windbreaks near the door opening. The more severe the climate, the greater the need for a buffer area, such as a cold porch, to separate the indoors from the outdoors.

Common Problems

- *Glass breakage.*
- *Frost build-up.*
- *Air leakage and heat loss.*
- *Failure of hardware.*
- *High condensation and freezing on windows to the point where they are inoperable.*

What to Look For
On a Set of Plans

A good set of working drawings will provide you with a window and door schedule. The schedule will detail:

- the number of windows and doors,
- the size of the rough openings, and
- the type of window and style of door.

In addition, the working drawings will note the location of the windows and doors, and detail the framing requirements for the rough openings. Examine the windows and doors, both for construction and placement.

Design Considerations

- At a minimum, install double-glazed windows. The best glazing is triple-glazing with two low-E coatings, and argon gas fill. The edge spacer should be insulative and the space between the glazings should be 12 mm (1/2”).

- Frames should be rugged – preferably wood – to reduce breakage during transport and while in use. Hardware should be heavy duty. Plastic components must be able to withstand extremely cold temperatures.

- The majority of windows should be on the south-facing side of the home. To avoid overheating, however, make sure that south-facing glass equals no more than ten per cent of liveable floor area. It is better to have one large window than two smaller ones.

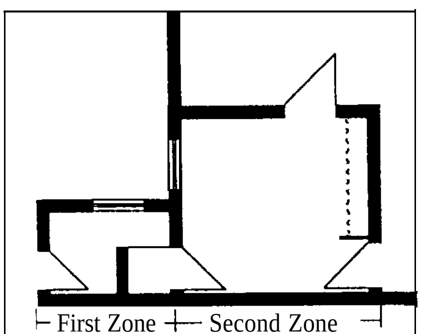
- Use windows that are non-opening – except where they must open to provide ventilation.

- Weatherstripping should remain flexible and functional at extremely cold temperatures.

- Doors should have an insulated core with good weather-stripping and low air leakage.

- There should be two entries/exits. Entrances and exits should be designed to avoid snowdrift build-up.

  Ideally, entrances should have a cold porch or vestibule separating the outside from the heated interior. This will help reduce the amount of heat lost with frequent opening and closing of the door. In extremely cold regions it is advisable to have two ‘buffer zones’.



Two Zone Entry

3.0 CHOOSING MECHANICAL EQUIPMENT

Increased insulation levels and tighter construction practices require that mechanical equipment be chosen and installed with great care and consideration to make sure that it operates efficiently and safely. This section examines heating and ventilation system options for energy-efficient housing in remote and northern areas.

3.1 *Heating*

The job of the heating system is to provide comfortable temperatures in the house during cold weather. While different fuels are used to generate heat, there are really only two methods of heat distribution: forced air heating and convective heating. (Wood heat is discussed in section 3.2.)

Forced Air

Forced air heating is the most common heating system in the far north. These systems are cheaper to install and cheaper to maintain than boiler/hot-waters ystems. Forced air systems are also ideal for heating, humidifying and distributing fresh ventilation air.

Common Problems

- *Basements are uncommon in the north. Ducting costs are higher, because they must be concealed.*
- *High electricity costs mean that it is expensive to operate the furnace fan.*
- *Energy-efficient houses often have oil-fired furnaces that are over-sized compared with the heating requirements of the house. This leads to inefficient operation of the furnace.*
- *Tighter houses need outside air supply for combustion furnaces to avoid backdrafting of chimney gases.*

Convective **Heating**

Convective heating systems are almost exclusively water/glycol-based (or hydronic) systems. Oil is burned in a boiler to create hot water which is then distributed by a system of pipes to radiators in each room. Hydronic heating systems can also be combined with the domestic hot water system. If properly maintained, these heating systems can last as long as the home.

Another advantage is that fans are not required, often resulting in lower operating costs when compared with forced air types.

Common Problems

- *They are the most expensive to install and require a great deal of maintenance.*
- *There are not as many trained or qualified service personnel, compared to forced air systems.*
- *Distribution offresh air is a problem in tighter houses using hydronic heating, which can create ventilation concerns (see section 3.3, Ventilation).*
- *As with forced air types, it is hard to find smaller capacity boilers for more efficient houses. Those that are installed are usually oversized and some what inefficient.*
- *Backdrafting of chimney gases is also a concern in tighter houses.*

Equipment Considerations

In deciding which oil space heating strategy is best for you make sure that the system you choose:

- will ensure health and safety for the occupants;
- can be installed and maintained easily and cheaply;
- performs as intended under all weather conditions;
- has adequate combustion air to prevent backdrafting of chimney gases;
- ensures a comfortable living space in the coldest weather; and
- is not oversized.

Remember too, that an open plan will help with hear distribution.

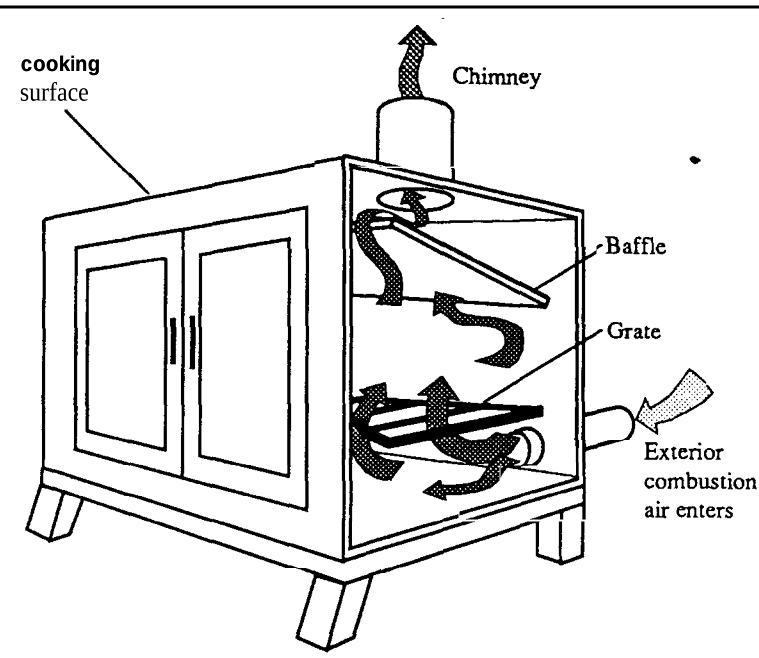
3.2 Wood Heating

In communities below the tree line, wood is often the - cheapest, and sometimes the only, fuel available. There are a variety of wood-burning products available but few meet the needs of remote northern communities.

While some problems encountered in wood heating are user-related, others can be avoided by a better choice of wood heating appliance and a well-planned installation. A house designed with wood heating in mind will maximize safety, comfort and ease of operation of the heating appliance.

Common Problems

- *Poor choice of woodburning stove – poor design, oversized or undersized unit.*
- *Flue problems – chimney fires, dripping creosote, icing chimney caps and plugged flues.*
- *Poor heat distribution resulting in cold floors, cold bedrooms, and a living room that is too warm.*
- *Safety – improper clearances of stove or furnace to combustibles.*
- *Poor maintenance .*
- *Long-term planning – no community plan for long-term access to proper fuel or for maintenance of systems.*
- *Inadequate air supply for combustion.*



High Efficiency Woodstove

Equipment Considerations

- The stove should have CSA certification.

- The stove should be capable of heating the house. It should be able to deliver heat for an eight-hour period without having to be reloaded. An undersized stove wi 11 often have to be reloaded day and night. An oversized stove will produce large amounts of creosote when operated at low bum rates. If in doubt, you are better to undersize than oversize.

- The house design should allow the heat to reach all parts of the house. If the stove is in the basement, an open staircase, open doors, or floor grates will help with distribution. If the stove is on the main floor, bedroom doors should face the living room. A small circulating fan will help distribute heat.

- The installation must be in accordance with CSA installation standards. This means that the proper clearance space has been maintained around the woodstove or furnace and its chimney. If not, wall or ceiling protection must be installed between the appliance and combustible building materials. The stove should be placed so that it does not block any exits.

- The plan should include a fuelwood box, fixed in place at least five feet from the stove. The design should include provisions for a covered fuel storage area and for easy winter access to the fuel. A reasonable quantity of fuel should be storable in the house.

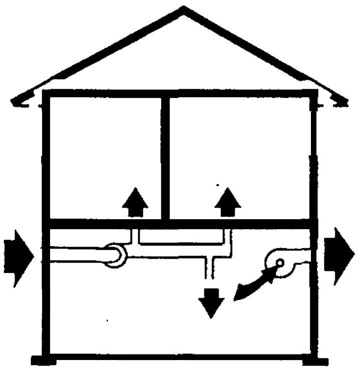
- The appliance should be placed close enough to the chimney to avoid long lengths of flue pipe.

- To ensure proper operation of the stove, consider the following:
  - use only stainless-steel insulated chimneys,
  - install the chimney inside the house,
  - use a small diameter chimney (6 inches),
  - use a short flue pipe,
  - consider a double-wall non-vented flue pipe, and
  - provide outside combustion air.

- The installation must be easy to maintain. Insulated chimneys inside a house should be installed with a base tee. The stove connection is then made through the side of the tee. The bottom of the tee is used for inspection and cleaning.

3.3 *Ventilation*

The purpose of a ventilation system is to remove stale, . indoor air and replace it with fresh air from outside. The two basic approaches to achieving this are mechanical ventilation and passive ventilation.



Balanced System

Mechanical Ventilation

Mechanical ventilation can be divided into three categories: exhaust only; supply only; and balanced systems. All three use a fan or fans to move air. The exhaust only system, using bathroom and kitchen fans, blows air to the outside, *repressurizing the* house. The supply only system draws air into the house, putting it under a condition of *pressurization*. A balanced system ensures that fresh air enters the house at the same rate that the stale air leaves. Balanced systems are usually packaged” units with a heat exchange core, and are referred to as *heat recovery ventilators* (HRVS).

Common Problems

- *Exhaust only systems repressurize the house and can cause combustion equipment (oil furnaces, woodstoves and fireplaces) to backdraft chimney gases into the house.*
- *Supply only systems pressurize the house and can push moist indoor air through the walls to the outside, leading to condensation problems inside the walls.*
- *The cold air brought into the house by a supply only system may need to be preheated.*
- *HRVS experience core freeze-up, resulting in long periods under defrost mode.*
- *There have been installation and maintenance problems associated with HRVs, especially in remote communities; however, newer equipment appears to work satisfactorily.*
- *Continuous fan operation under these approaches ca lead to unacceptable operating costs.*

Passive Ventilation
Passive systems usually do not require fans. Instead, intentional openings in the lower floors or walls allow fresh outside air to enter. As the air is heated, it rises due to the *stack effect*, and passes to the outside through openings in the upper part of the house. This air exchange can also occur due to the *wind effect*.

The main advantages of the passive approach is its simplicity of operation and low installation and operating costs. Its main disadvantage is that it is still a relatively new ventilation strategy and its longer term performance has yet to be assessed.

Common *Problems*

- *The reliance on stack and wind effects can result in wide variations in airflow rates.*
- *These systems may not meet pending ventilation standards.*
- *There is no capability to recover heat from the exhausted air.*
- *The problem of tempering the incoming fresh air still exists.*

Equipment Considerations

An airtight home must have a ventilation system. In deciding which of the above approaches is best for you, make sure that the system chosen will:

- ensure optimal health and safety for the occupants;
- be installed and operated at a reasonable price;
- perform as intended under all weather conditions;
- be easily maintained, and its operation and controls clearly understood; and
- ensure a comfortable living space in colder weather.

3.4 Lights

It has been estimated that the average household in the far north commits 30 to 50 % of its annual electrical bill to lighting alone. Lighting technology has seen impressive efficiency improvements over the past five to ten years. The cost-effectiveness of these improved lighting technologies, particularly in areas where electricity rates are high, is equally impressive.

Incandescent

The standard incandescent light bulb is familiar to everyone. It can last anywhere from 750 to 1,500 hours and is relatively inexpensive to buy. However, it is only about 15% efficient in its ability to produce light. That means about 85% of the energy consumed by the standard incandescent is wasted as heat. Over the relatively short lifespan of the bulb, its energy or operating cost can be 40 to 50 times greater than its initial purchase price. It is important to keep this "second price tag" in mind when making lighting purchasing decisions.

Fluorescent

Fluorescent bulbs, although efficient, have not experienced wide acceptance in residential applications, mostly for aesthetic reasons. Recent improvements – particularly the development of compact fluorescent bulbs – have meant that fluorescent units can now be used in virtually all lighting applications in the home.

Conversion adapters have been available for several years which allow small fluorescent tubes to replace standard incandescent. Recent improvements have seen the tubes bent into a dome shape and enclosed in an outer plastic globe, similar in shape to a conventional incandescent bulb. The newer compact fluorescent are unitized, incorporating a disposable electronic ballast, which eliminates the annoying "pulsing" problem of earlier magnetic ballasts. The tubes are also colour corrected to provide the "soft" light associated with incandescent.

But this is where the similarities end. These new compact fluorescent last on average 10,000 hours while using about 80% less electrical power compared to an incandescent of similar light output. They are considerably more expensive to purchase, but the "second price tag" of these bulbs – namely the electrical costs to operate them – may be less than the purchase price.

3.4.1 Appliances

The cost of operating major appliances (refrigerator, freezer, stove, etc.) can be prohibitively high in remote and northern areas. The refrigerator is the most energy-intensive appliance in the home, excluding the electric water heater.

Refrigerators currently available in Canada can consume anywhere from 73 to 165 kWh/month, as determined by referring to the Energuide label found on all appliances sold in Canada.

Given the very high electricity costs in the north, selecting the appliance with the lowest available Energuide rating is a wise economic decision. For example, compare the operating costs of the two example refrigerators below.

Model A:

- 150 kWh/m x $.50/kWh x 12 months= $900/yr
- Assume 15-yr service life= $13,500 lifetime cost-

Model B:

- 100 kWh/m x $.50/kWh x 12 months= $600/yr
- Assume 15-yr service life = $9,000 lifetime cost

costs:

As can be seen from this example, a more expensive, efficient refrigerator saves $300 per year and $4,500 over the 15-year service life of the appliance. If, for example, the energy-efficient refrigerator cost $50 more to buy than the other refrigerator, a savings of $300.00 over twelve months means you save $25 every month. And that means that you recover the price difference of $50 between the two refrigerators after only two months.

It makes a great deal of economic sense to select the lowest available Energuide rating when purchasing any appliance.

4.0 RETROFIT TECHNIQUES

It's easy to build an energy-efficient home from the ground up. But what can you do to a house that already exists? Most people live in older homes which are not energy efficient. These houses can be cold and drafty in winter, hard to heat and uncomfortable.

Retrofit is the name given to energy-efficient renovations – improving existing houses. A retrofit is a good.idea for many reasons.

- It will make the house much more comfortable, without drafts or cold parts of the house.
- It will save on heating costs. Very little work can usually save 10% to 20% of your heating costs. A little more work may save 30% to 50%. In some cases, a complete retrofit can save 70% or more.
- It will help to protect your house from moisture damage.

Retrofit can be done all at once if you are doing a major renovation. Or it can be done a little at a time over the years. Whatever your approach, you should keep in mind the same ideas:

- Stop air leakage through holes and cracks around the house.
- Add insulation whenever and wherever you can.
- Have your heating system working well with enough outside combustion air.

Every house has to be treated differently. A newer house may only require some minor, low-cost retrofits. An older house that is in need of repairs and is not energy-efficient may need a lot more work. It might not be worth spending a lot of time and money on a very old house that is on its last legs.

4.1 Minor Retrofits

Even a newer house can be improved. Most of the improvements are low-cost or just require a different way of operating the house. Generally the work doesn't require special tools or skills, and doesn't take much money. These retrofits will pay for themselves very quickly, often within months.

- Air seal around windows, doors, and any other places the air gets in or out of the house. V-type weatherstripping is easy to apply around windows and doors, while a. good-quality caulking will seal other holes.

- Add a plastic sheet to windows with only one or two layers of glass or those that aren't used in the winter. A heat-shrink covering goes on easily and is invisible.
- Make sure your heating system **is** properly tuned. This is for safety as well as energy-efficiency.
- Lower thermostat settings, especially at night or if no one is home in the day. Newer thermostats can do this automatically.
- Turn down the temperature of the hot water tank.
- Install an insulating-jacket on the hot water heater. Kits are available to make this an easy job.
- Install a water-flow **restrictor** on showers.
- If you have a engine block heater, install a timer so it is on for only a couple of hours before you need it.

4.2 Moderate Retrofits

These retrofits require a greater investment of time and money. However, they are all worth doing if your house falls under any of these categories. Many of these retrofits can be done by anyone handy with basic tools, although some are best left to professionals who have the proper training and equipment. These measures should pay for themselves within a few years. Take a walk through your house, looking at the energy-efficient features and what potential there is for improvement.

- Many houses need air leakage control beyond just sealing windows and doors. It's very important to seal properly in order to stop air from escaping into the-attic, where it leaves moisture. Basements, or floors above crawl spaces, have a lot of air leakage, as do the areas around chimneys, vents, and other penetrations. You should also consider moisture control and ventilation to reduce the chance of condensation problems.
- Many houses will benefit from a complete heating system tune-up. This should correct any problems with the furnace or boiler, the distribution system, and the controls. Replace old units with a high-efficiency model.
- Replace an old woodstove with an airtight model. Old barrel stoves are both inefficient and safety hazards. Install a duct from the outside to provide combustion air. Also, replace unsafe flue pipes and chimneys.

- Insulate a poorly insulated attic, if there is less than 150 mm (6 in.) of it now. Glass fibre and cellulose insulation are both good in attics. It is important to provide a good air seal frost.
- Insulate an empty frame wall. If there is no insulation in a frame wall, it is worthwhile blowing in insulation to fill the cavity. Sometimes loose-fill insulation can be poured into the cavity from the attic.
- Insulate the basement or crawl space. Basements and crawl spaces are areas of high heat loss in most houses. You can insulate from either the inside or outside.
- Add storm windows. Double layers of glass are necessary, and triple layers are needed in very cold climates. Consider adding interior storms – either permanent or seasonal. If the windows are beyond repair, try and replace them with high-performance windows.

4.3 Major Retrofits

Almost all repairs and renovations you do around the house can have an energy-efficient component piggybacked onto the work. Renovation provides an opportunity for adding insulation, air-sealing the house, and installing an air and vapour barrier.

Insulation by itself is not expensive. It is the preparation, construction, and finishing details that can increase costs. If you are doing the work anyway because of renovation plans or repair work, there is little extra cost involved in adding insulation and air-sealing.

- Walls from the interior. Replacing interior wallboard provides an opportunity to check on the condition of plumbing, heating ducts, and wiring, replacing where necessary. It also allows for higher insulation levels and a new air and vapour barrier. You can make the old wall cavity bigger to allow for more insulation by cross-strapping the studs or building a new wall in from the old.
- Walls from the exterior. Re-siding or other exterior work allows for reinsulating. Install an air and vapour barrier over the old wall. Create a cavity for insulation by cross-strapping or by building a new wall that is supported on a ledger plate, hung from the rafters, or attached to the old wall. Insulate, then cover the cavity with building paper and siding.

- Foundations. Make sure that the foundation is structurally sound and stable. Otherwise, if the foundation shifts, additional leaks and cracks may be opened up in the building shell.

  Generally speaking, full basements are not common in remote or northern areas. Where they do exist, they can be retrofitted by adding additional insulation on the interior or exterior. Crawlspaces, which are common, can be retrofitted in the following manner. Dig a trench to – but not below! – the footing level. Damp-proof the foundation and then insulate. Insulation above grade level must be covered and protected with flashing. If the crawlspace has been left open, it will be necessary to insulate the cavity created by the floor joists.

- Attics and roofs. Sometimes it is necessary to replace a rotten roof. The roof can be sealed and built up to allow for higher levels of insulation.

- Windows. Replacement windows should be at a minimum double-glazed or have a "Low-E" coating. There is also the opportunity to reduce the size of north -facing windows and increase the size of south-facing windows. Replacement doors should have an insulated core.

- Total Retrofit. Some major renovations allow for a total retrofit. This is when you can install a continuous air and vapour barrier and high levels of insulation throughout the house. This means a complete transformation of the old house to levels of energy-efficiency that are normally only met in new housing.

4.4 *Considerations*

Changing one aspect of a house causes changes to happen in other aspects. It is important to understand and plan for these reactions.

- Humidity levels will go up as the house is made more airtight. If humidity levels rise too high, so that too much condensation or frost appears on double windows, you will have to try to decrease the moisture you put into the air or increase ventilation.

- Lack of fresh air maybe a problem as the house becomes tighter. Extra ventilation may be required. It wil 1 have to be done in a controlled way that doesn't cause discomfort.

- Supply combustion air to all fuel-burning appliances such as furnaces and woodstoves and fireplaces.

PART TWO
THE CASE STUDIES

This section of the catalogue features fifteen examples of new house construction, and five examples of retrofits.

Each of the new house examples were assessed and chosen for meeting specific criteria: energy-efficiency, occupant suitability, durability, ease of maintainance, and construction skill requirements. Each case study takes up four pages:

The first page shows an illustration of the house and its floorplan.

Page two looks at basic construction issues; the materials and techniques used and the type of mechanical systems in "operation. When available, energy performance data has been included.

Page three details the features that make each house particularily suitable for remote or northern regions.

Page four contains 'feedback' information gathered through (telephone) interviews with the designer / architect, builder and occupants— providing insight into the how the house was designed, how the construction progressed, and what the house is like to live in and operate.

We've also included costs and contacts. The names, addresses, and telephone numbers of people who can provide more information, and in some cases plans, are included for those interested in a particular set of plans.

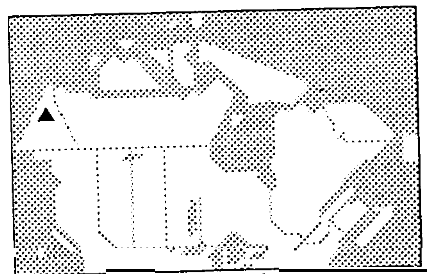
The costs of the houses have also been included where information was available. The costs are reported as built – in the year when the houses were built – and may no longer be accurate. Costs will also vary from region to region depending on the costs of materials, transportation and labour. Several of the houses were owner-built using 'sweat equity' — the cost of which is not included in the finished price. Be careful not to be swayed by the listed costs. You'll have to do your own homework to determine a price for your own community.

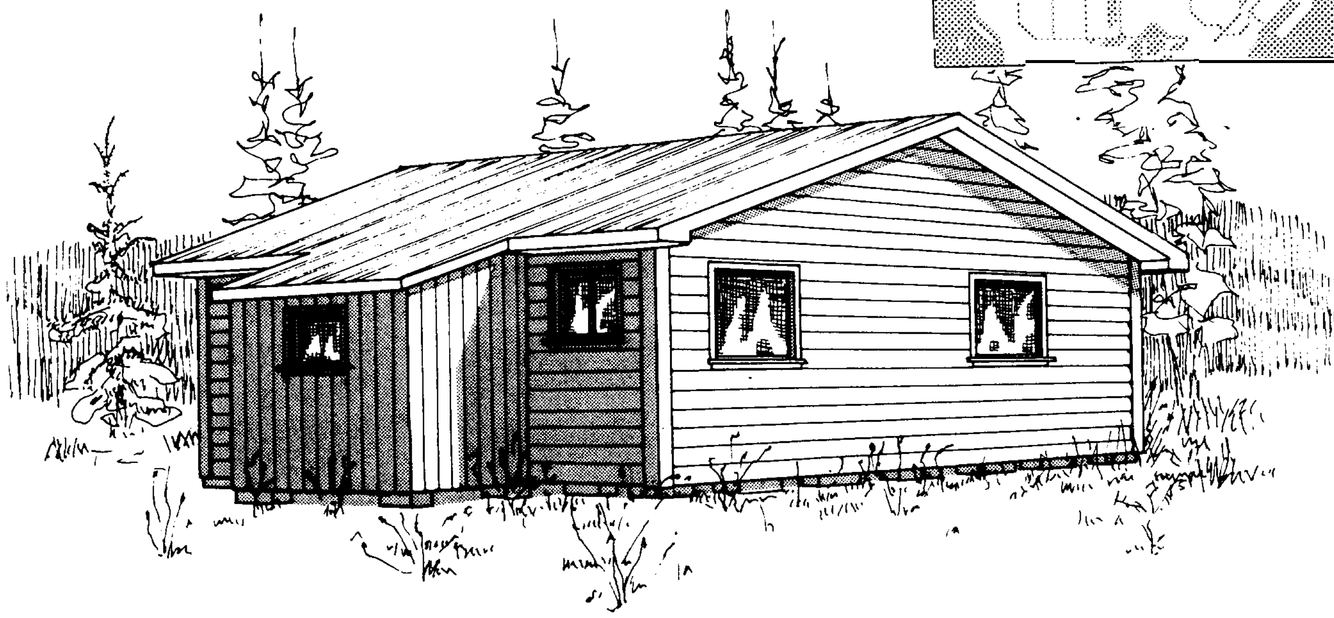
The five retrofit case studies contain examples of retrofits performed to the different levels as outlined in the primer. In each case, the location, project history, description of the retrofit, results and paybacks are examined.

Index to the Case Studies

* *The asterisk indicates that the Remote Community Demonstration Program was involved in the project.*

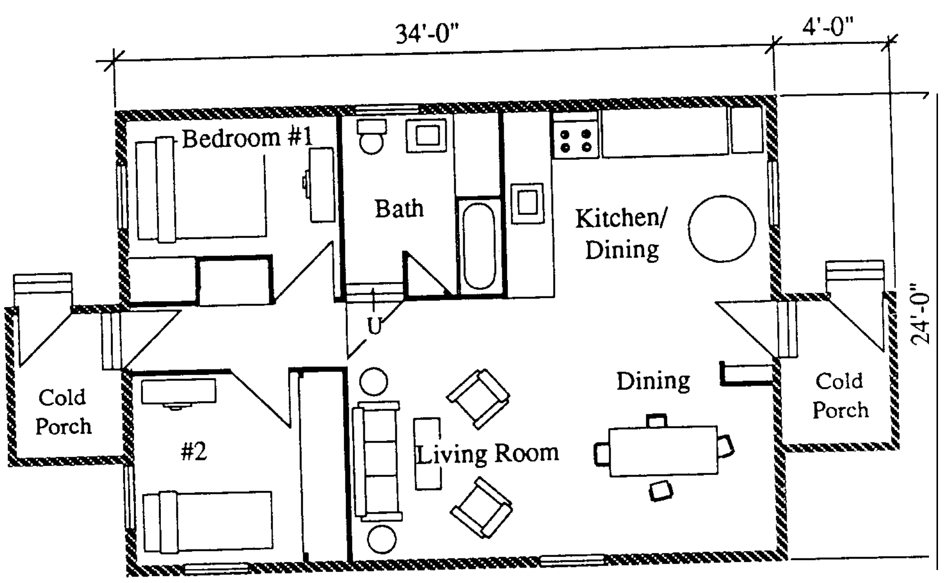
OLD CROW - YUKON TERRITORY





This is a compact two-bedroom bungalow. Constructed in Old Crow, 60 miles north of the Arctic Circle, the design is ideal for northern and remote locations where transportation restrictions, permafrost, and extreme cold are the norm.

Dimensions -7.32 m x 10.37 m (24' x 34'}
Finished living area – 75.88 m' (816 sq ft)
Unfinished living area – O
Cold porch -8.92 m' (96 sq ft)



CONSTRUCTION

The foundation is pressure-treated wood pads and wedges on gravel pads, constructed on ice-rich permafrost soils. The gravel pads provide a stable material to support the foundation against the annual freeze-thaw cycle. The wood pads transfer the weight of the house to the gravel, while the wedges allow the foundation to be levelled when necessary.

Exterior wall is construction is 38 x 140 mm (2x 6) studs with 38 x 64 mm (2 x 3) interior strapping Both cavities are filled with glass fibre insulation. A 6 mil polyethylene vapour barrier is sandwiched between the frame wall and the strapping. A sealed Tyvek air barrier is wrapped around the outside of the house.

The exterior is finished with a locally cut log veneer, while the interior is finished with panel board. The panel withstands foundation shifting better than gyproc.

38 x 286 mm (2x 12) joists are used for the roof, which is an unvented cathedral ceiling. The interior is strapped to create an electrical chase.

Thermal Values:
Foundation floor - RSI 8.4 (R50)
Above-grade walls - RSI 4.9 (R28)
Attic - RSI 7.0 (R40)

OPERATION

The house is heated by a centrally located woodstove. The open plan allows the heated air to move freely. Ceilings are sloped, and the partitions do not extend to the ceiling. The short walls allow heat from the wood stove to circulate more freely, but may increase the amount of noise heard from room to room. The combustion air for the stove is brought in from the outside, directly underneath the stove.

Ventilation is supplied by a VanEE 1000 heat recovery ventilator. The HRV is run at low speed, and there is a manual switch that allows residents to turn the unit off when it's not needed.

The plumbing system includes a 250 gallon water tank and a 350 gallon sewage holding tank. The bathroom has been designed to include both tanks within the thermal envelope to prevent freezing and allow them to operate at low water volumes.

All taps are non-freezing, and with self-draining hose bibs there is no need for back-up heat. The entire system can quickly and easily be drained to prevent freezing when the house is vacated for extended periods.

PERFORMANCE

While energy consumption has not been monitored except in a very informal way, it is obvious that this house is performing extremely well. Whereas other, more typical houses in this area consume anywhere from twelve to fifteen cords of wood over a heating season, only three or four cords of wood are needed to heat this model. In fact, some residents have commented that the house can get too hot!

NORTHERN FEATURES

This home is a unique example of northern and remote housing in several ways.

1. It is designed to be simple and compact.

2. It is designed to be energy-efficient – in fact, it is an R-2000 house, but not registered under the program since it is owner built.

3. It is designed for permafrost areas, with a perimeter leveling system and full span floor trusses.

4. It contains an unvented or 'hot' roof which prevents snow from entering the attic.

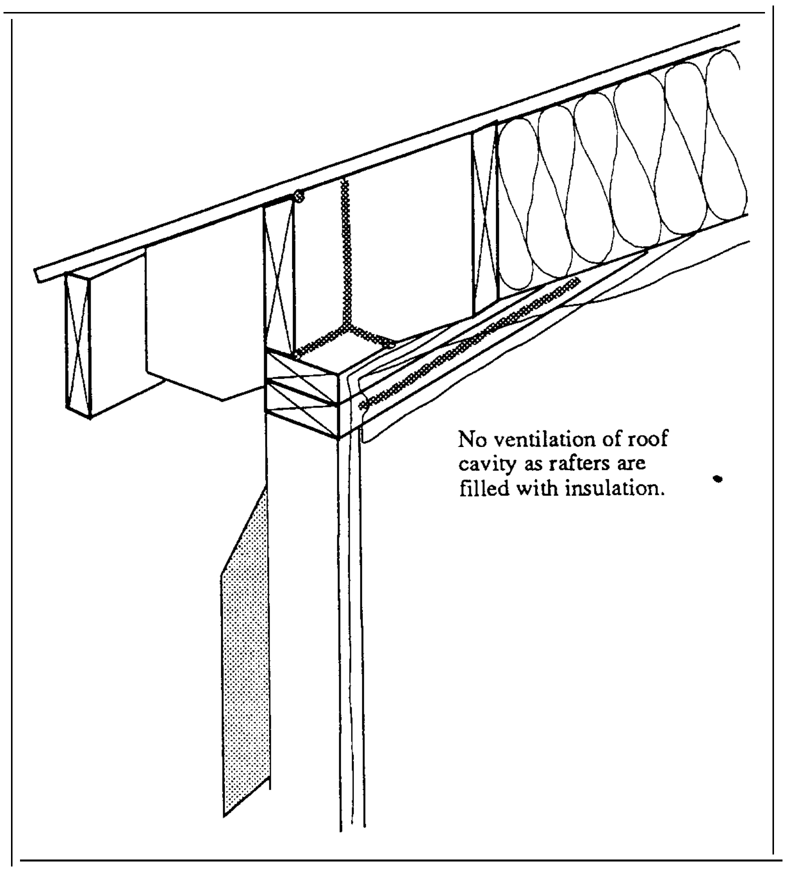
Hot Roof

Most building codes require that roofs/attics be ventilated to prevent a build-up of moisture. In the north, drifting fine-grained snow more often than not finds its way into the attic through openings provided for ventilation. Combined with the long winters and the potential for frost build-up, ventilated roofs may suffer severe moisture damage.

The concept of a sealed and unventilated roof has recently been developed. Some refer to this as a 'hot roof'.

The success of an unventilated roof depends on having a nearly perfect air-vapour barrier in the ceiling. This means more emphasis on quality control when installing the air barrier system.

Proper ventilation of the house interior also becomes a priority; this helps to maintain the indoor humidity at reasonable levels, which in turn reduces the impact of any air movement that does occur through holes or breaks in the air-vapour barrier.



DESIGN AND ARCHITECTURAL NOTES

The house was designed by Northern Cadworks, a Whitehorse-based architectural firm with several years of experience in northern housing. While this house in particular contains elements that have evolved over time, the clients themselves were responsible for the main design.

"Fundamentally, the house was designed to be compact and well-insulated house, " says Rob Mason. " By compact, I mean well thought out. For example, the kitchen and bathroom should back onto each other to reduce the amount of piping and to ease the servicing – especially water – of the building."

It was also important that the house survive in a permafrost area. The foundation is designed to be flexible, to handle some movement, but the perimeter support system means that there are ultimately fewer points that can move. The clear span trusses increase the rigidity of the floor assembly, so that any movement will have a minimal effect on other components.

BUILDER – RESIDENT REVIEW

This house was built by the eventual owner under a CMHC demonstration program. A construction manager was hired by CMHC to oversee the project. The construction manager instructed clients in the basics of construction and helped them through difficult spots. The architect was also available to answer questions and provide assistance.

The houses are well thought out and relatively easy to construct. They have been kept small and simple with a minimum of framing materials. There is not a whole lot in the way of 'specialized' skill required. The key to building the houses is essentially in the training.

According to the architect there were very few problems encountered during the construction process, other than those typically encountered by those building a house for the first time. "The basic problem is that people don't realize the amount of work of time involved. They want the house to be finished now, right away. "

Feedback indicates that residents are happy for the most part. Clients were presented with the shell and package of amenities that could be delivered within the budget. Room layout and location of windows, doors and finishing details were left up to the clients.

COSTS AND CONTACTS

The cost of the Old Crow unit was $55,000 in 1987 dollars. This includes $14,000 for freight and $41,000 for materials.

Labour was supplied by the client under a sweat equity agreement.

For further information contact:
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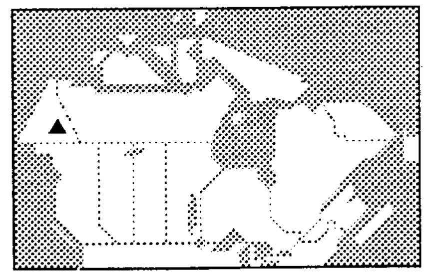
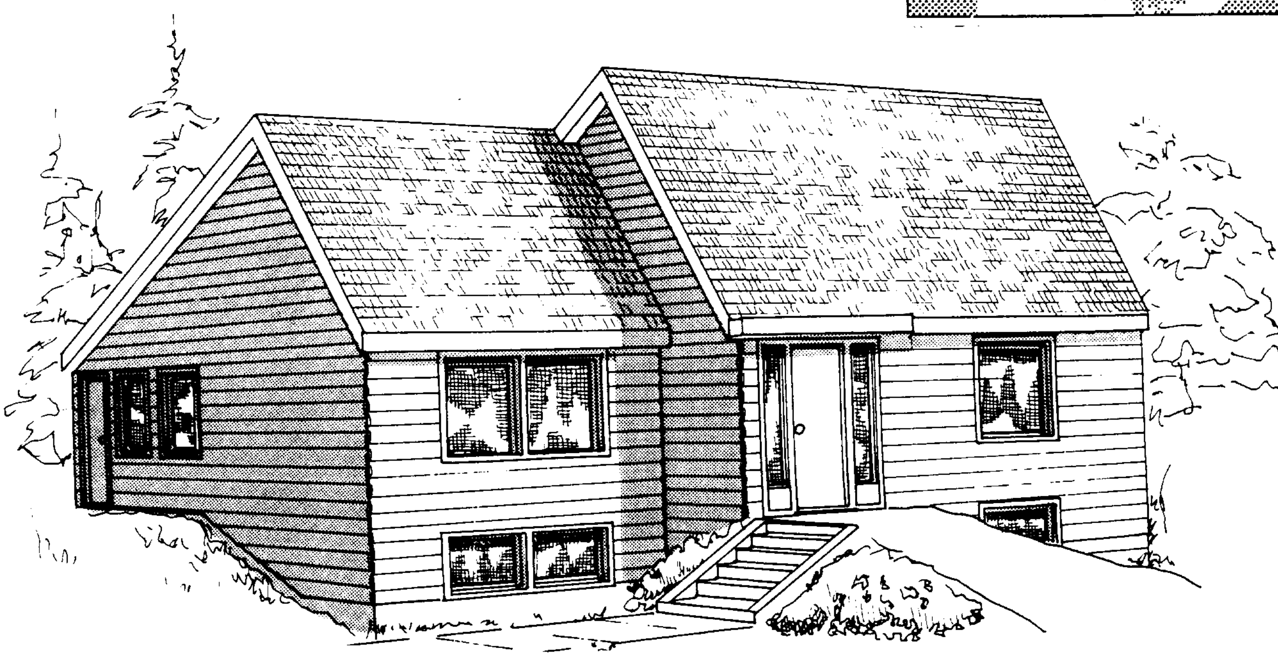
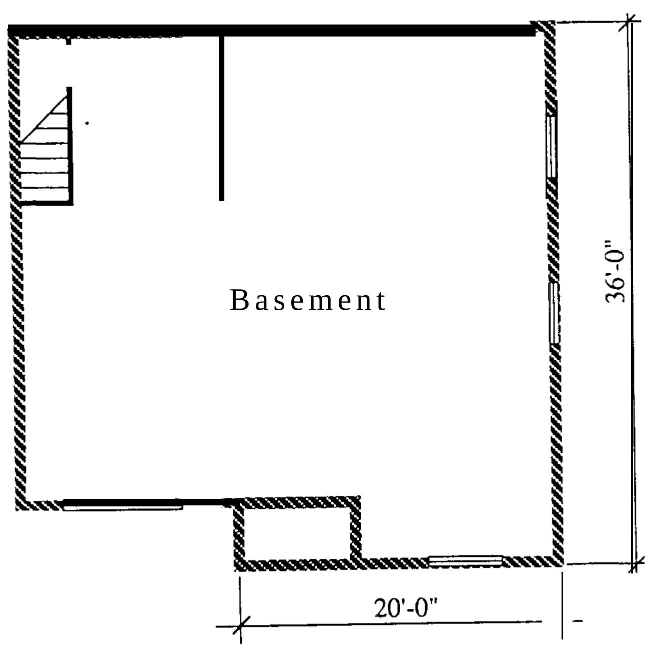
PELLY CROSSING – YUKON TERRITORY

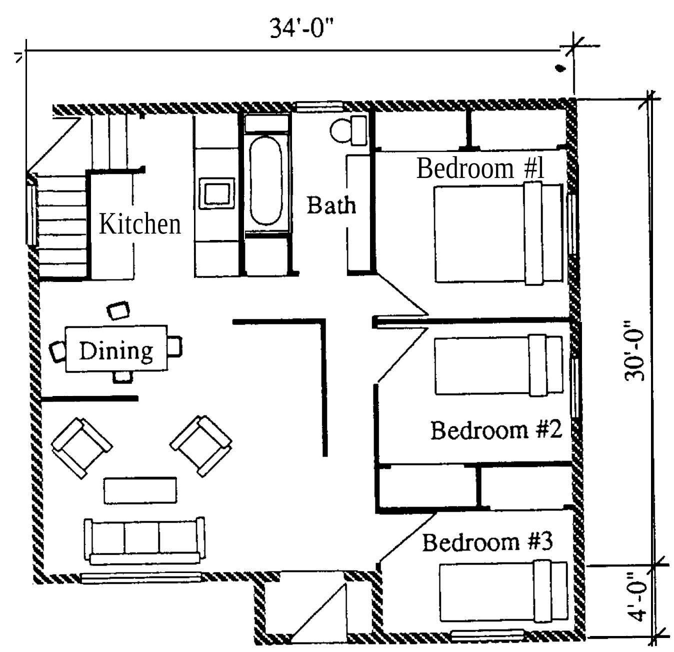




This is a three-bedroom, split-level house built to R-2000 standards. Constructed in Pelly Crossing, 160 miles north of Whitehorse, by members of the Selkirk Band. It features an open living space, and a full basement for storage or additional living space.

Finished living space -102.5 m² (1103 sq ft)
Unfinished living space -102.5 m' (1103 sq ft)
(The dimensions shown in the floorplan are approximations only.)





CONSTRUCTION

The foundation consists of 38 x 190 mm (2x 8) pressure treated studs, insulated and finished on the inside with gypsum board, and sheathed on the outside with pressure treated plywood. The wood sleeper floor houses insulation as well, which means that the basement floor is more comfortable underfoot should the basement be finished off and used as living space.

The above-grade walls are 38 x 140 mm (2x 6) studs with 38 x 64 mm (2 x 3) interior strapping. The interior is finished off with gypsum wall board; rough-sawn 25 x 190 mm (1 x 8) siding is used on the exterior. A polyethylene air-vapour barrier is sandwiched between the studs and strapping to protect it from punctures.

The roof is composed of engineered high heel trusses.

Windows are triple glazed wood casement and are located mostly on the south and west sides. The air-lock entry has an insulated metal inner door and wood outer door with double insulating glass.

Thermal Values:
Foundation floor - RSI 2.1 (R12)
Foundation – RSI 4.9 (R28)
Above grade walls – RSI 4.9 (R 28)
Roof - RSI 7.0 (R40)

OPERATION

Heat is provided by both a woodstove located in the basement and an oil-fired space heater.

Coils are provided at the woodstove to preheat the domestic hot water. Warmed water flows up to the storage tank, while the cooler water drops to the coil near the stove to be heated.

The ventilation is provided by a VanEE 2000 HRV.

PERFORMANCE

While the house is as warm and comfortable as one would expect from an R-2000 structure, the electrical costs are higher than originally anticipated. The higher costs were mainly attributed to the fan on the HRV.

It must be remembered, as well, that this house is relatively large by northern and remote standards and consequently the running costs should be expected to be higher.

However, even with the increased power consumption, running' costs are still lower than conventionally constructed houses of a similar size.

FEATURES

This house has a number of features worth noting for those involved in the design and construction of remote and northern housing.

1. The unit is compactly designed to minimize surface exposure to reduce heat loss.

2. Roof overhangs are provided only where necessary to reduce the effects of summer solar gain.

3. Each unit is oriented to maximize solar gains.

4. The existing landscaping is used to buffer the effects of prevailing north-westerly winter winds. In addition, berming to the north assists in deflecting wind.

5. The full basement provides lots of storage, and additional living space if necessary. While the house is not large by typical urban standards, for a northern and remote community it is a fair sized house ideal for large families.

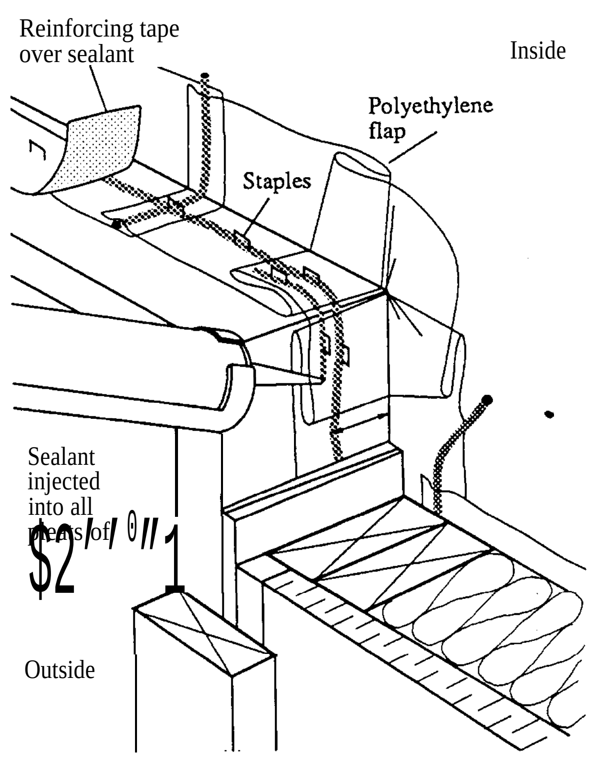
6. Airtight building shell.

R-2000

An R-2000 home is not the result of a specific design, but a home that meets a certain standard for energy-efficiency.

To meet these 'standards' the R-2000 program sets out minimum levels of ventilation and above-grade wall insulation, types of windows, and types of appliances. The cornerstone to the house, however – and to any low-energy home – is the demand for airtightness. This is achieved by an air-vapour barriers ystem.

In the Pelly Crossing house the air-vapour barrier was a polyethylene sheet which had been caulked at the seams to forma continuous, 'unbroken' membrane. Windows and doors also form part of the 'building envelope' and must be as airtight as possible. This is one of the toughest areas to deal with when trying to ensure that the air-vapour barrier is continuous. The diagram shows one way of 'tying' a window (or door) into the main air-barrier with a polyethylene system



DESIGN AND ARCHITECTURAL NOTES

The house was designed by Patti Rao exclusively for a remote area, using R-2000 construction techniques, mainly to see if the technology was appropriate in such a setting.

It was also designed to suit the lifestyle of the residents as much as possible. The house is divided into three clearly defined zones: a living zone, a sleeping zone and a circulation/ service zone. There is plenty of storage, and the basement provides a large work or living space. The living area is located to the south-west comer of the house so that it benefits most from the passive solar gain.

BUILDER NOTES

The majority of the actual construction was carried out by the band members themselves; with plumbing, heating, ventilation, and electrical work performed by sub-trades with R-2000 experience. Site supervision was provided by the Dena Ku, a native construction firm operating out of Whitehorse. According to the Dena Ku, as well as band members, the construction process went quite smoothly.

Both the Dena Ku and several members of the Pelly Band had some R-2000 training. While it is not critical that this always be the case, it is necessary that the supervisor have R-2000 training and be able to transfer the special requirements of the program to the crews – in particular, the need for an air-tight, continuous air barrier.

RESIDENT REVIEW

While the houses performed well for the most part, residents expressed a number of concerns that future builders should consider. The fuel oil storage tank is located at the exterior of the building near the HRV intake. This resulted in fumes being drawn into the building. It would be far better to strengthen the sleeper floor and then put the tank in the basement.

With the woodstove located in the basement, tenants complained that the basement become extremely hot before the main floor reaches a comfortable level.

In the future, if the basement is to be used primarily as storage, locate the woodstove upstairs. Or use a wood-fired forced air furnace to ensure better distribution of heat.

Tenants also expressed a desire for better windows and in particular window hardware.

Finally, it was suggested that a short, simple, easy-to-read manual be developed which can stay with the house and be used by new tenants to help them with the operation of the HRV.

COSTS AND CONTACTS

The Pelly Crossing houses were built at an approximate cost of $110,000 per unit, in 1986 dollars. Of this, 10% is directly attributable to the features associated with R-2000.

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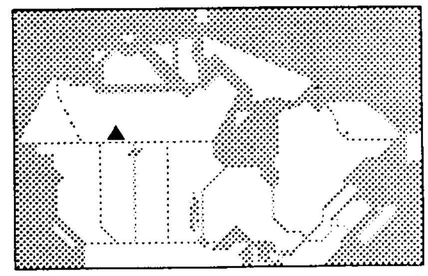
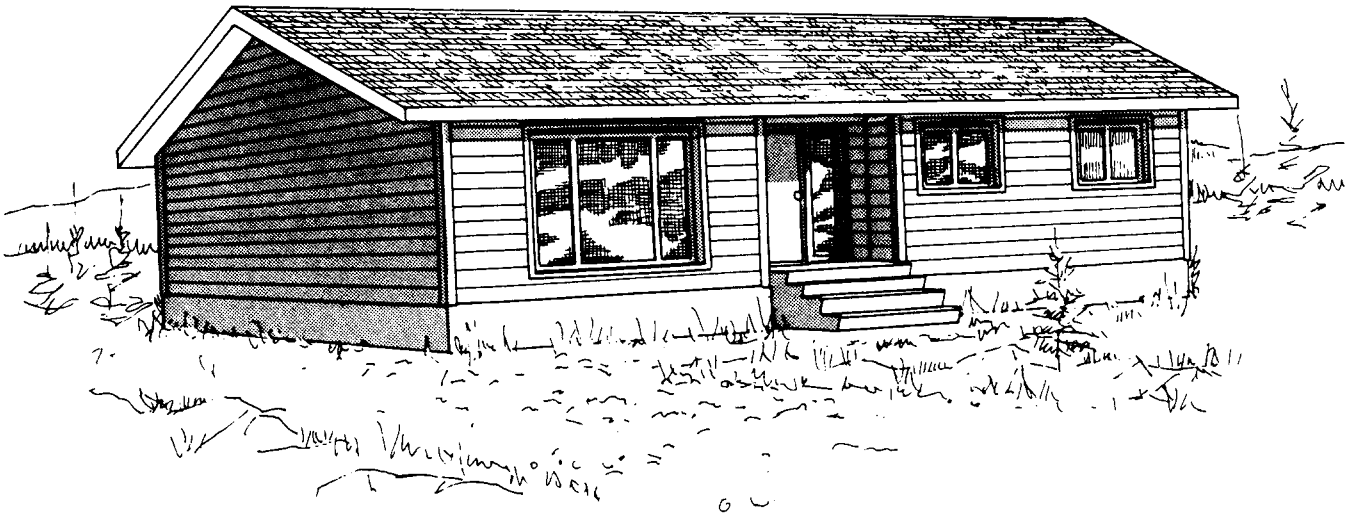
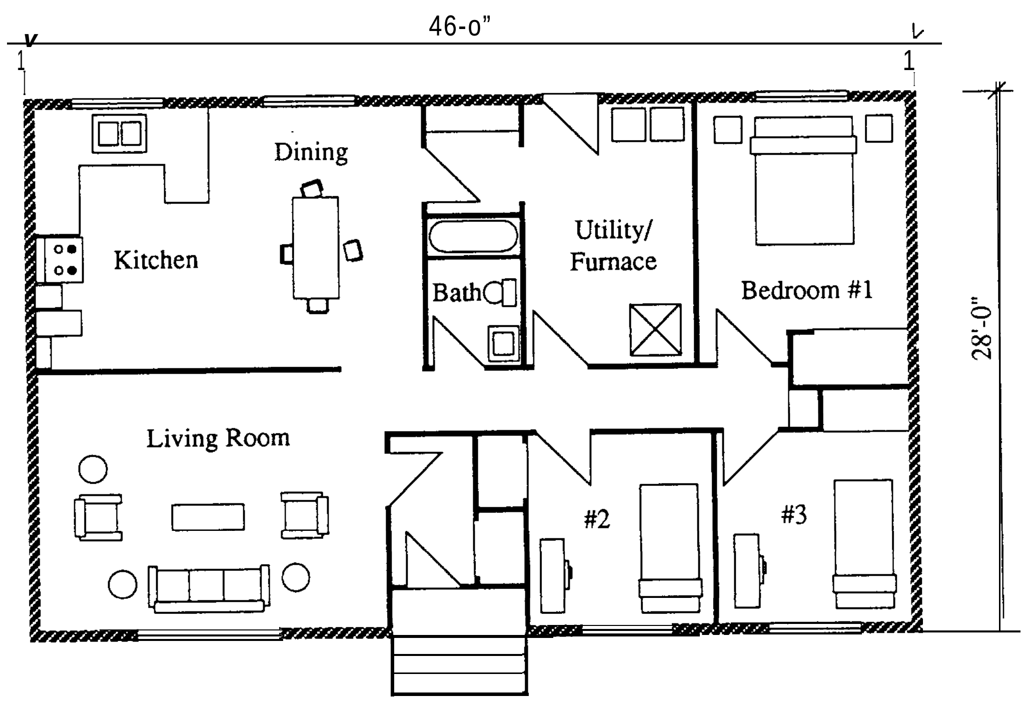
HAY RIVER – NWT





This is a three-bedroom bungalow constructed in Hay River, NWT. It features a modular wall system with an R-2000 rating and a space frame foundation. Heat is supplied mainly by a centrally located wood-stove.

Dimensions -14.03 m x 8.54 m (46' x 28')
Finished living space -119.78 m^2 (1,288 sq ft)
Unfinished living space – O



CONSTRUCTION

The house is built on an experimental space frame foundation. The floor itself consists of 38 x 286 mm (2 x 12) joists filled with glass batt insulation.

The exterior wall is 38 x 140 mm (2 x 6) studs filled with glass fibre insulation. 38 mm (1.5") of styrofoam SM was added to the exterior of the shell to bring the total wall value up to RS1 4.9 (R28).

Wall sections were prefabricated by Nelson and Great Western Homes Ltd. in Lloyd Minister, Alberta and shipped by truck to Hay River.

A 6 mil polyethylene air-vapour barrier is located on the interior.

The windows are double glazed with a low-E coating.

Thermal Values:
Foundation floor – RSI 7.04 (R40)
Exterior walls - RSI 4.9 (R28)
Attic - RSI 10.56 (R60)

OPERATION

Heat is supplied primarily by a centrally located wood stove, with an oil-fired boiler as back-up. The combustion air for the stove is brought in directly from the exterior to the foot of the stove.

Four other houses of similar design, built at the same time, used a passive ventilation system.

This unit was equipped with a heat-recovery ventilator – a VanEE 1000 – as part of the R-2000 requirements.

A 1,000 gallon fibreglass water tank is housed in an insulated chamber under the back porch. The septic tank is stored underground at the rear of the structure.

PERFORMANCE

Energy performance data for the Hay River houses was in the process of being collected at the time of printing.

Original estimates for energy consumption for space and water heating and appliances were 150 imperial gallons of oil, and 12,295 kWh of electricity.

Preliminary data indicates that these figures will be close to the estimates of the actual consumption.

NORTHERN FEATURES

This unit has a number of features that make it an attractive option for remote and northern locations.

1. Energy-efficient design.

2. The prefabricated design means it can be erected very quickly, and with a minimum of construction skills.

3. Relies primarily on wood heat.

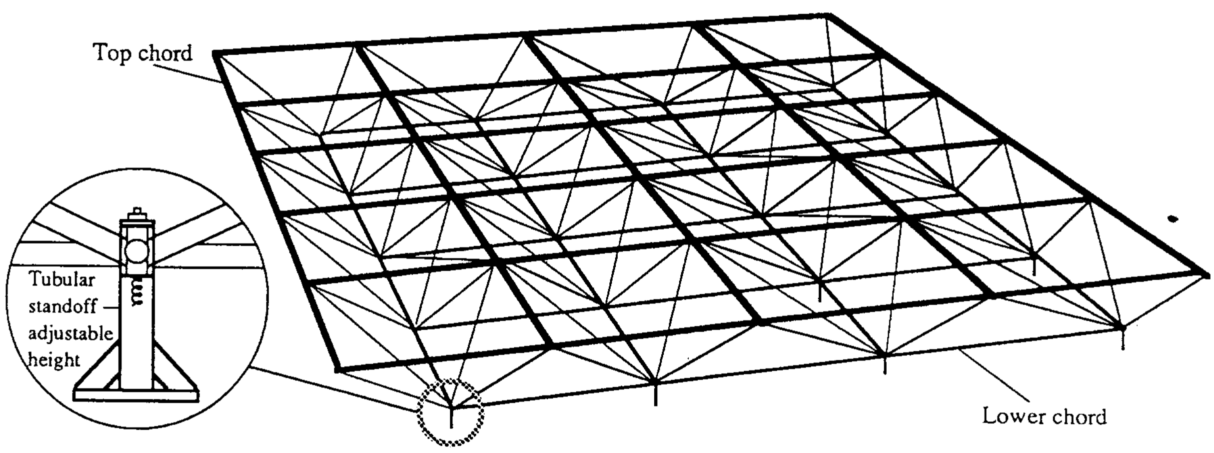
4. The space frame foundation.

Space Frame Foundation

Most foundations are designed to provide a stable base for the house. Unfortunately, if the foundation shifts, the result is usually cracked drywall, windows and doors that no longer open and close properly, separated walls and roofs, and expensive repairs. Space frame foundations are designed to move with the soils. If the foundation tilts, the whole house tilts. This prevents damage to the structure. The whole structure can later be re-levelled.

Because it requires so little site preparation, the space frame seems ideal for areas where equipment and materials are difficult to obtain.

Besides providing a level base for the house, the open nature of the foundation provides space for services such as a septic tank. The system seems very cost-competitive, especially when the increased house-life expectancy and reduced repair cost are taken into account.



The space frame foundation built in Hay River is known as a multi-point system. It uses a light aluminum-steel alloy. It took three unskilled labourers and one manufacturers' representative only three days to erect.

While still in an experimental stage, this foundation appears to be the most promising solution for areas with permafrost or discontinuous permafrost.

DESIGN AND ARCHITECTURAL NOTES

Nelson and Great Western Homes have been designing prefabricated homes for remote and northern communities for several years. They have a variety of designs, which they like to add to or change each year. However, there is only so much that they can change. "We like to give people a variety of designs, but you're dealing with a prepackaged design and with the north. There is only so much flexibility available within the confines of northern construction demands."

It's a good design, extremely simple and highly replicable. It is designed for permafrost conditions, but would easily sit on other types of foundations.

BUILDER NOTES

The house was built by the Tu Chu Gha, a local Dene housing association. Because the band has a lot of experience with prefabricated housing, and even with the changes associated with this house (e.g. the space frame as opposed to the traditional heated crawl space approach), there were no major problems.

"You need just one person who really knows what they're doing, and four hands that know how to swing a hammer. There is nothing complex about these houses. They represent what northern housing should be – simple, quick to build, and warm."

RESIDENT REVIEW

The residents find the house to be open, and very comfortable. It is easy to heat, and relatively maintenance free. This is particular y important since both of the parties living in the house hold full time jobs. Their only concern is with a lack of storage space.

While it seems that the house could be heated almost entirely with the woodstove, since both people were working they found themselves relying more on the oil-fired boiler.

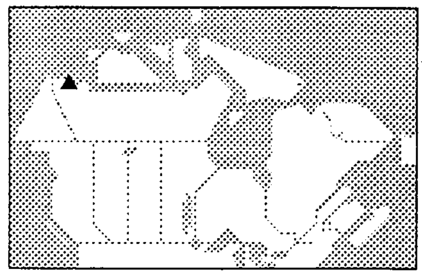
COSTS AND CONTACTS

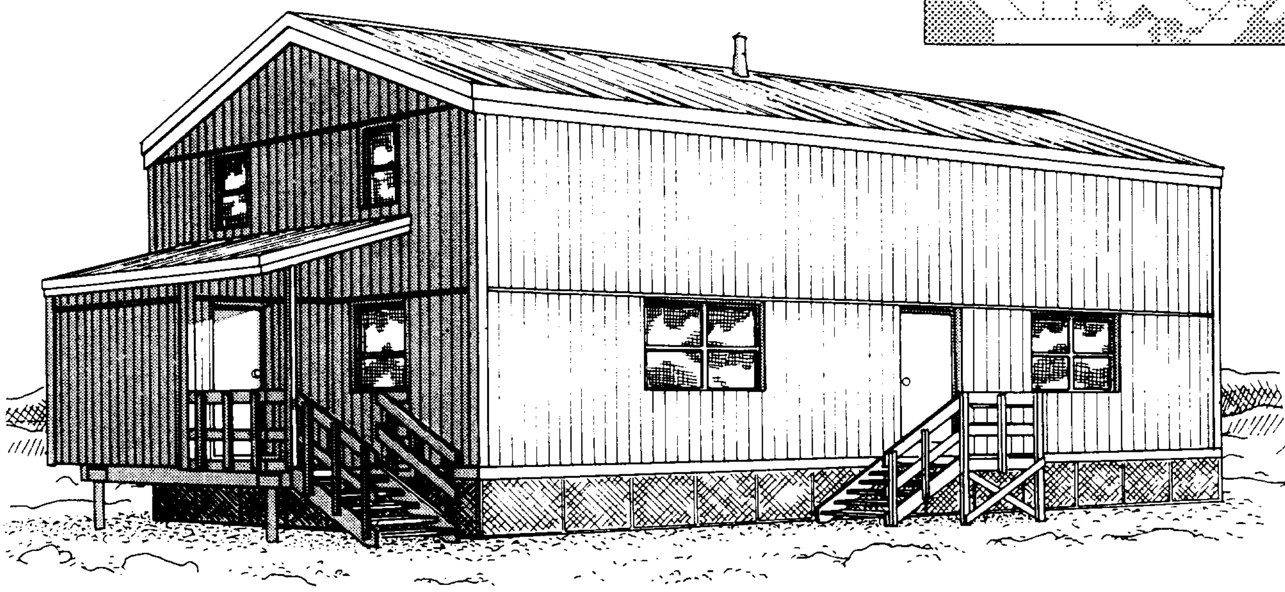
The Hay River house was built in 1987 for an approximate cost of $75,000. The cost of the space frame was $12,000.

For further information contact:
Tu Chu Gha Contracting
Hay River, NWT
(403) 874-6701

For information concerning the space frame foundation contact:
Rob Duncan
CMHC
682 Montreal Road
Ottawa, Ont. KIA 0P7
(613) 748-2349

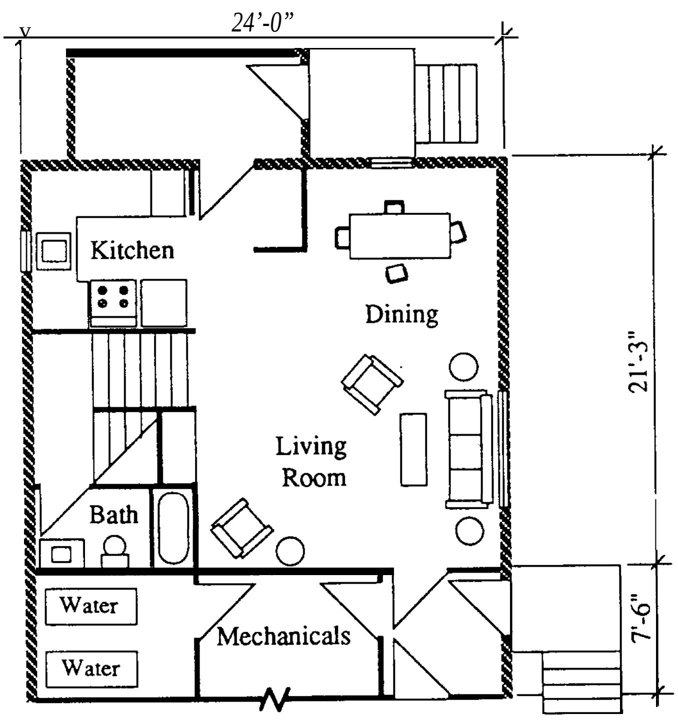
INUVIK – NWT

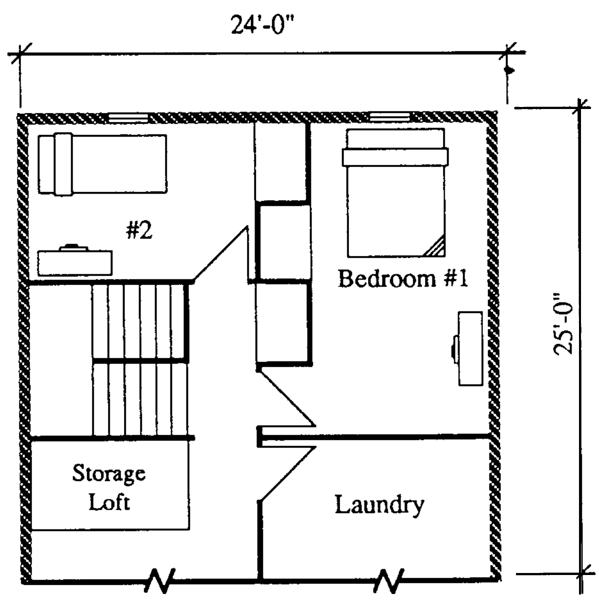




This is a two-storey, two-bedroom duplex designed for areas above the tree line. The design makes efficient use of space. Entrances are protected by both a vestibule and a cold porch. The two-s torey structure provides good separation between the public and private areas.

Dimensions -7.32 m x 15.25 m (24' x 50')
Finished living space – 223.2 m^2 (2,400 sq ft)
Unfinished living space – O
Other (cold porch) -13.39 m^2 (144 sq ft)





CONSTRUCTION

The house is constructed on permafrost soil using a wood pad and wedge system on a gravel pad. A wire mesh skirting is used to keep the bottom of the elevated house cold.

The exterior walls are 38x 140 mm (2 x 6) construction filled with batt insulation. 38 x 38 mm (2 x 2) exterior strapping is used to hold additional semi-rigid insulation.

The roof is 38 x 235 mm (2x 10) rafters with 38 x 38 mm (2x 2) exterior strapping. The ceiling is unventilated. On the interior, the air-vapour barrier is sandwiched between two layers of gypsum board for better protection against punctures and tearing.

Windows are sealed double-glazed awning units with a 'piggy-backed' pane added on the outside which acts as a storm window.

Thermal Values:
Exposed floor - RSI 5.64 (R23)
Exterior wall - RSI 4.9 (R28)
Roof – RSI 7.04 (R40)

OPERATION

All the mechanicals are housed in a common room, and shared by the two units. While the heating system, for example, is relatively expensive, the common mechanicals mean the unit works out to be both cheaper and easier to maintain.

Heat is supplied by a hydronic system using an oil-fired boiler. The boiler is housed in the mechanical room and is supplied with a seperate outdoor combustion air intake.

A passive fresh air system is used to supply fresh air for the occupants. Passive air ducts and exhaust fans are used to keep the humidity level in check. A false floor with a gap at the perimeter walls is provided to all first floor living areas – except the bathroom. Warm air gathered at the top of the house is recirculated through a stud space in the wall to the lower floor and via the false floor.

The water tank and sewage holding tank are contained within the thermal envelope to prevent freezing. The bathroom is situated one-half-storey above the frost floor, which allows the placement of a sewage holding tank beneath the floor and creates additional storage space above.

PERFORMANCE

A report on the energy performance of the duplexes was not available at the time of printing. According to the residents in Inuvik the duplex is one of the warmest houses they have ever lived in.

Given the levels of insulation and attention to detail, these duplexes should prove to be an extremely energy-wise decision.

FEATURES

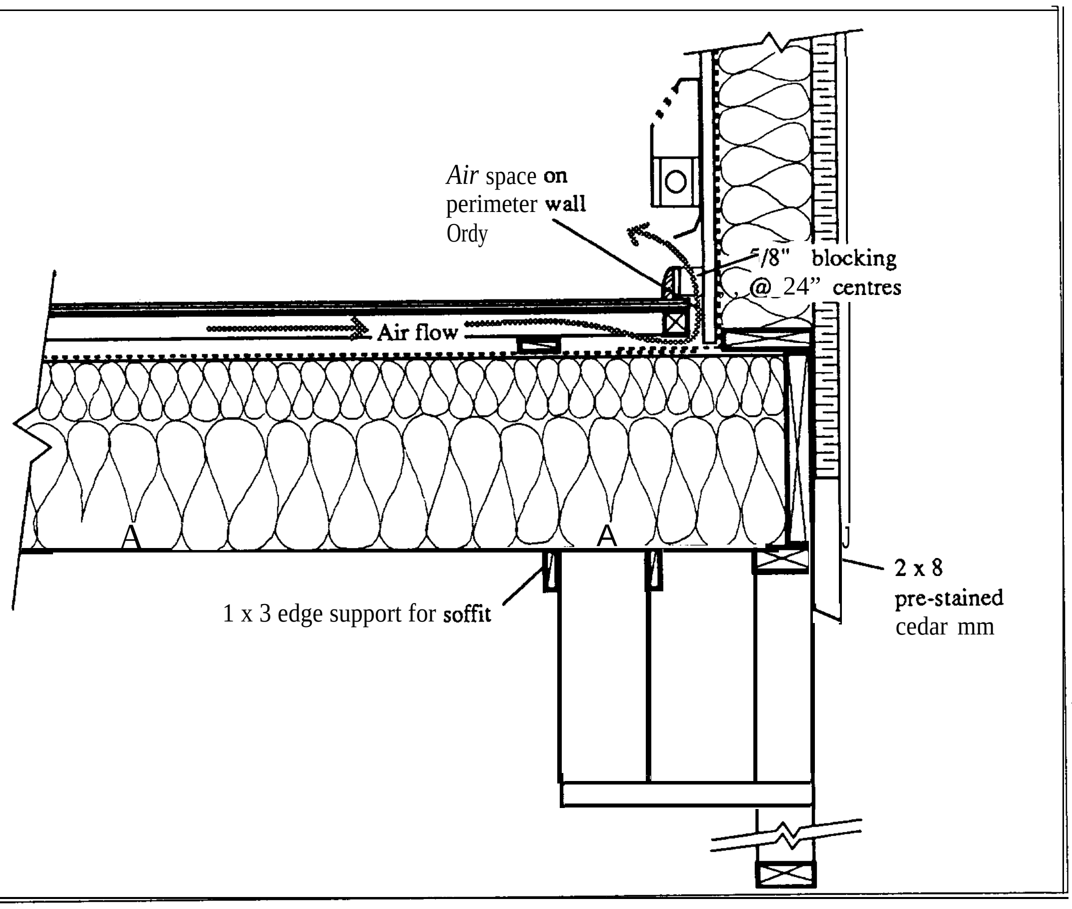
This house is the product of years of evolution. It contains a number of features which make it particularity suitable to northern and remote areas.

1. The foundation system.
2. The unventilated roof.
3. The cold porch and vestibule.
4. The passive ventilation system.

False Floor

One of the most common problems in remote and northern houses that are 'elevated' from the ground is a cold and uncomfortable floor. This house solves that problem with a 'false floor' that acts as a warm air return.

Warm air gathered at the top of the house is recirculated passively through a stud space in the wall to the lower floor and via the false floor.



A false floor with a 3/4" gap at the perimeter walls (see section detail) is provided to all first floor living-dining-kitchen areas.

This recirculation of air prevents a build-up of warm air at the ceiling, and keeps the floors warm and comfortable underfoot.

DESIGN AND ARCHITECTURAL NOTES

Northwest Territories Housing Corporation develops their designs using a design team and input from the community. The designs are updated and modified on a yearly basis.

The main requirements, according to Marsh Wilson of NWTHC engineering division are, "that the houses be cost-effective, durable, flexible – that is they must be replicable in lots of areas – and of course energy-efficient. The continuity of designs helps to ease construction, and they are a whole lot easier to maintain."

BUILDER NOTES

"The design is excellent," says contractor Lloyd Woloshyn. "NWTHC wanted a low energy house that was relatively easy to maintain, and they have succeeded."

"For a builder, the houses area pleasure to construct. They are extremely well thought out, and probably the most complete set of plans I have ever seen, which makes it very important that you pay strict attention to detail. There are a lot of components, and they are very intertwined. If you miss a step, you have to go back and start again."

"One thing new builders might have a small problem with is the cathedral ceiling. You have to frame the roof; it is not a truss roof. You have to do all the measuring. It means that you might have to go back and hit the books."

"One other area of note is the wall that goes up to the gable end. The plans call for the floor joists to end flush with the outside wall, which means you have to frame the second storey wall and then drop it down to sit on the top plate of the first storey wall. Well, everyone changes this and extends the joists out over the top plate, and then you can just frame the second storey wall in a natural fashion."

The houses take anywhere from two to three months to construct, depending on the skill level of the crew. All you need though is one experienced lead hand and three helpers.

RESIDENT REVIEW

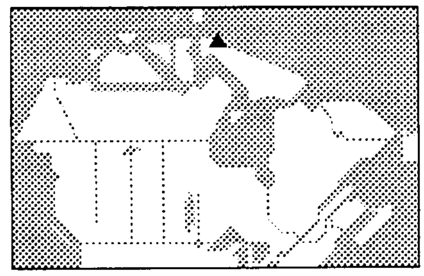
Residents find the houses to be warm, comfortable and easy to look after. There is an abundance of storage space, and the living areas are open and spacious. In Inuvik, however, the community is on a utilidor system, and so the space alloted for the water and sewer tank is essentially wasted. The residents of this particular unit also found that the noise from the fan that returns the air to the ground floor through the false floor return took some getting used to.

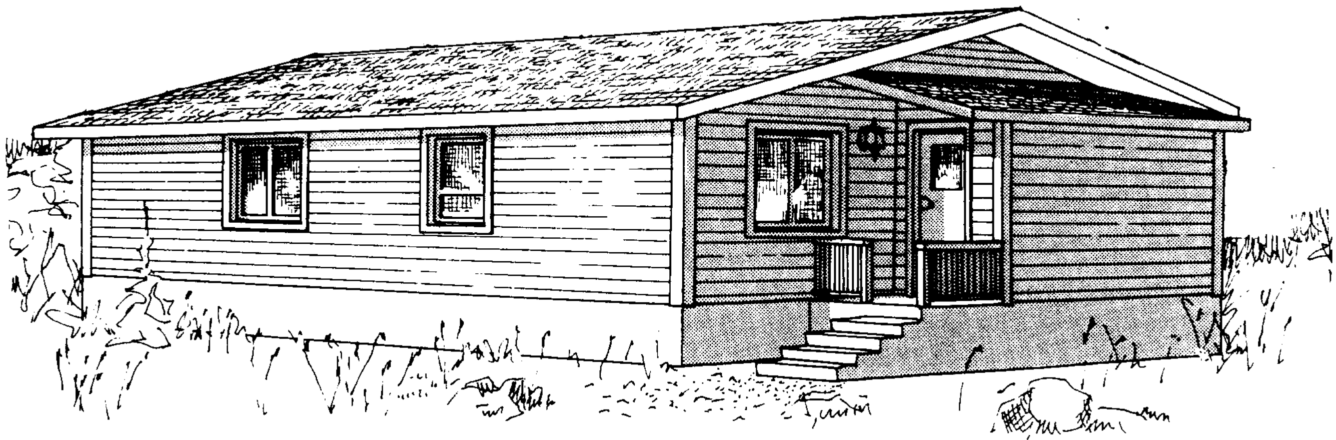
COSTS AND CONTACTS

The cost of the duplex built in Inuvik was $200,000 in 1986 dollars. For further informstion contact:

NWTHC District Office
P.O. Box 2200
Inuvik, NWT, XOE OTO (403) 979-4421

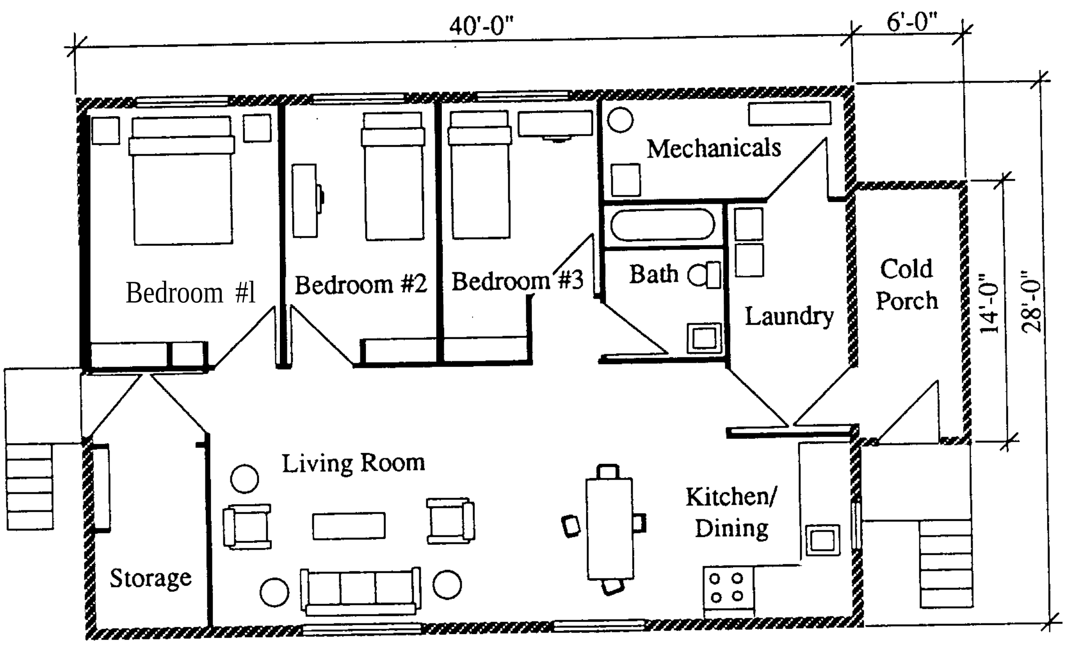
POND INLET – NWT





This is a one-storey, three-bedroom house, one of several designed by the Northwest Territories Housing Corporation, under the Housing Assistance Program. These houses are intended to be owner-built. They feature covered entries, large storage areas and a nice division between public and private living spaces.

Dimensions -8.54 m x 12.2 m (28' x 40')
Finished living space -104.16 m^2 (1120 sq ft)
Unfinished living space – O
Other (cold porch) -7.8 m^2 (84 sq ft)



CONSTRUCTION

After site preparation – which ensures proper drainage away from the house – a foundation of gravel pads with wood pads and wedges is installed around the perimeter. The floor joists are 2 x 10 filled with two layers of batt insulation. A Tyvek air barrier is fastened to the underside of the joists with staples and the seams are taped.

The exterior walls are constructed with 2 x 6 framing. The exterior is covered with plywood sheathing, a Tyvek air barrier and siding (either horizontal cedar siding, rough sawn plywood siding, or milled log cedar siding).

On the interior, a 6 mil polyethylene air-vapour barrier is installed, followed by a gypsum board finish.

The roof is 2 x 12 rafters with two layers of batt insulation.

Thermal Values:
Foundation – RSI 3.52 (R20)
Exterior walls - RSI 3.52 (R20)
Attic - RSI 7.04 (R40)

OPERATION

There are a number of heating systems to choose from, depending on what is best for a particular area. A central oil-fired furnace can be installed, which circulates air through a ductwork system installed in a false floor. In this case, the oil tank is located outside the building. A combustion air intake brings outside air into the mechanical room and provides ventilation of the room for proper fuel combustion.

Alternatively, a woodstove can be used as the primary source of heat.

A passive ventilation system is used – consisting of PVC pipes in insulated wall cavities – to supply and distribute fresh air.

Where municipal piping services are not available, cold water is supplied by a pressure system from a holding tank to the house plumbing fixtures. The same pressure system runs cold water through a water heater and then to the fixtures that require hot water.

Where municipal piping is not available, sewage is collected in an insulated fiberglass sewage holding tank, installed below the building. In this case, two heat traces are provided – the first one is active, the second one is an emergency back-up. The heat traces are hard wired to the electrical panel, and are thermostatically controlled.

PERFORMANCE

Performance information not available. However, the relatively low insulation levels suggest it is suitable for remote and northern areas with less extreme cold temperatures than the Artic

The resident has found the house warm and it keeps the heat in very well.

FEATURES

While the relatively low insulation levels in the walls does not recommend it for Arctic areas, the house does contain a number of features that make it suitable for northern and remote areas with less extreme cold temperatures.

1. A simple design that reduces wind pressures.

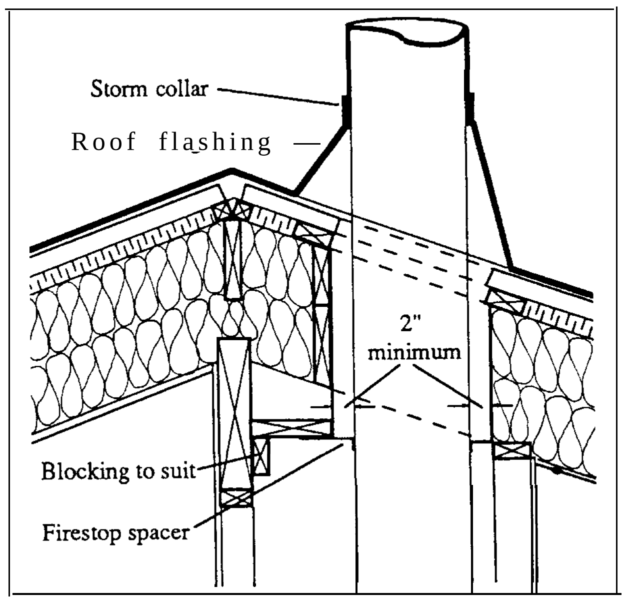
2. While designed with piped services in mind, the house can be easily modified to meet a number of temperature and locational criteria.

3. Plenty of storage space, with an open living area and good separation between public and private space.

4. Since the houses are owner built, the construction process has been simplified to aid in quick construction, especially important where the skill levels may be in a learning stage.

Chimney Detail

Probably the highlight of these houses is the manual that has been put together to assist the builder in their task. It contains clear, concise, and extremely thorough information from site preparation through to putting on the shingles. The diagram pictured here is from the HAP Construction Manual, and deals with chimney openings in the roof.



Where chimney openings occur, framing members should have a 2“ minimum clearance for fire protection and the sheathing should be securely nailed to the rafter and to the headers around the opening. (Consult the manufacturer’s written instructions for installation procedures.)

DESIGN AND ARCHITECTURAL NOTES

This house design was developed under the NWT Housing Corporation Homeownership Assistance Program (HAP).

HAP provides land, a materials package, and a limited labour component – generally limited to site development and electrical work – for low-income families.

A construction supervisor is provided by the NWTHC to oversee and manage each project. The rest of the labour is provided by the clients themselves under a sweat equity agreement. The capital costs are split equally by the NWTHC and CMHC.

The NWTHC provides a variety of house plans, all of which have been tested in previous years, and all of which meet a high standard both in terms of space and the quality of materids.

Design changes instituted by clients are allowed under the rules of the program, provided that the structural integrity of the house is not affected.

The designs are developed without a specific area in mind, and, as a consequence, are extremely flexible in order to suit a variety of locations.

The NWTHC also provides a limited amount of training for unskilled clients. Training is both personal and videotape based.

BUILDER AND RESIDENT REVIEW

The resident of the unit located in Pond Inlet found the house quite easy to build. The instructions were clear, specific, detailed, and easy to follow.

He took six months to finish the unit, but did not work at it steadily throughout that time. For the frost three months he had three people helping him. For the last three months it was just himself and his brother.

While his brother is a journeyman carpenter, he felt that even with his limited construction background he would have had little trouble building the unit.

He enjoys living in the house. He likes the general layout; and despite having only RSI 3.52 (R20) in the walls the house is warm, easy to heat, and keeps the heat in very well.

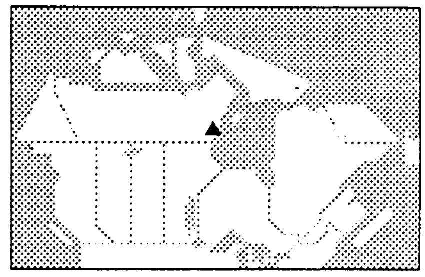
COSTS AND CONTACTS

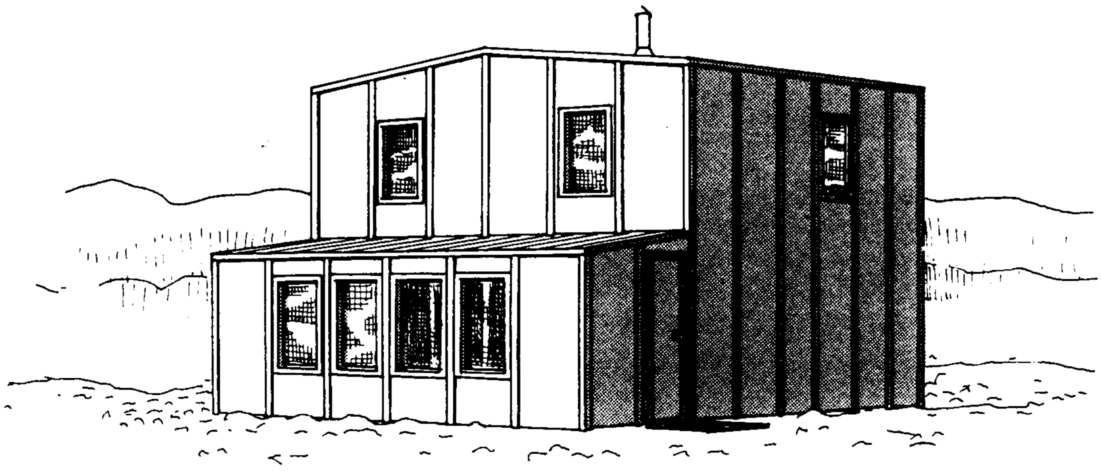
The cost of the HAP House built in Pond Inlet was approximately $81, 000 in 1987 dollars.

materials – $46,000
freight -$23,000
other – $12,000

For further information contact:
NWTHC District Office
P.O. Box 418
Iqaluit, NWT, XOA OHO
(819) 979-4421

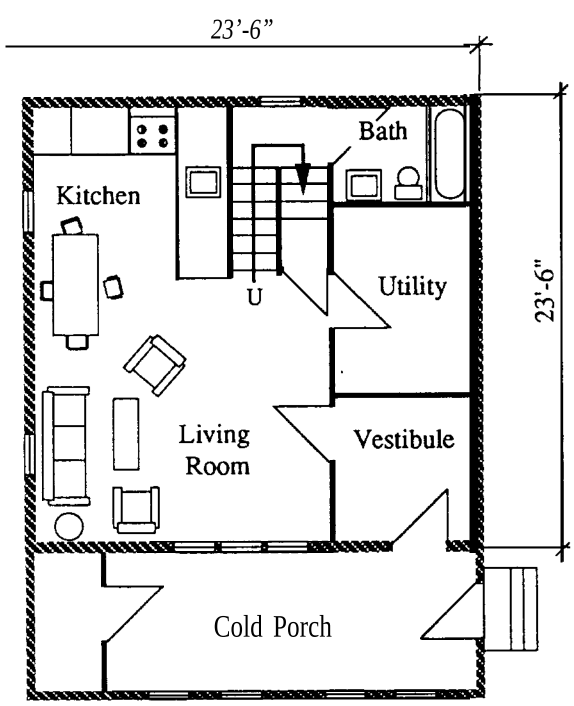
KEEWATIN – NWT

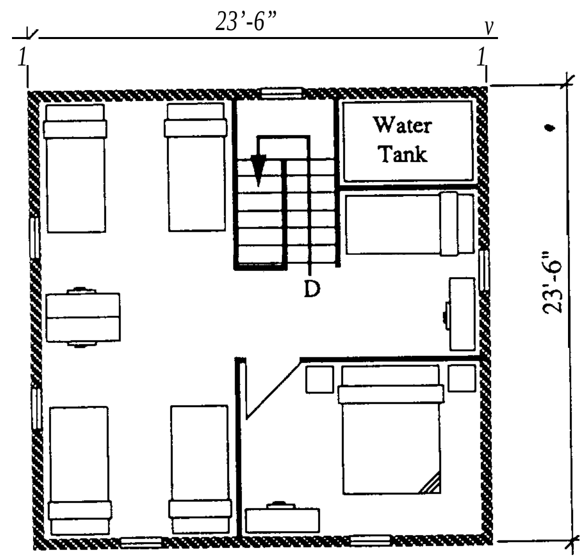




An experimental house, designed for the high Arctic, that uses a fraction of the energy required by conventional northern houses. The building is airtight, highly insulated, and compact. A south-facing cold porch provides a thermal buffer to the air-lock entry. The interior layout is open for improved heat circulation and also permits planning flexibility.

Dimensions -7.16 m x 7.16 m (23'6" x 23' 6")
Finished living space – 102.67n?(1,104'6" sq ft)
Unfinished living space – O
Other (cold porch) -17.48 m² (188' sq ft)





CONSTRUCTION

A perimeter wood grade beam foundation system maintains permafrost conditions under the house throughout the year, and provides a sealed, draft free crawl space. While the foundation system has been successful, a space frame foundation might now be a more appropriate choice.

A low-cost wall system was developed to accommodate great thicknesses of insulation. The hardboard interior finish also serves as the air-barrier. The deep, light weight insulated rigid truss is cheap to fabricate and speedy to erect and close in.

The roof is an 'atticless' construction consisting of preprinted corrugated steel panels and fir sheathing.

Windows were triple-glazed units and doors were steel, insulated, and entrances had a double airlock.

Thermal Values:
Foundation floor – RSI 8.8 (R50)
Exterior walls - RSI 7.04 (R40)
Attic - RSI 10.56 (R60)

OPERATION

The main heat source for the building is a centrally located space heater controlled by a non-electric thermostat which functions norreally during power outage. Heat radiates to the lower floor and warm air rises by convection up the stairwell to heat the upstairs.

A manually operated fan blows hot air from the peak to the first floor ceiling plenum which distributes it to the perimeter of the building.

Fresh air enters the house via a multiple plate reverse flow heat exchanger, which retrieves most of the sensible heat from the kitchen and bathroom exhaust air.

Fresh water is stored in a cistern at the top of the house and gravity feeds to all fixtures. Waste water and sewage drain into a holding tank under the bathroom. A low-volume flush toilet reduces water consumption.

PERFORMANCE

Attention to detail and the integration of a variety of measures to reduce energy consumption and increase the thermal efficiency of the building has resulted in a house which has minimum dependency on fossil fuel supplies in one of the harshest climates on earth.

FEATURES

The house, while designed and built in the early 1980's, nevertheless contains a number of features of special note.

1. It was designed to be constructed and closed in four days' time.

2. It contains a large cold porch area, with a double airlock, which acts as a wind buffer and provides additional storage space.

3. Both the septic storage and the fresh water supply storage are located within the building envelope.

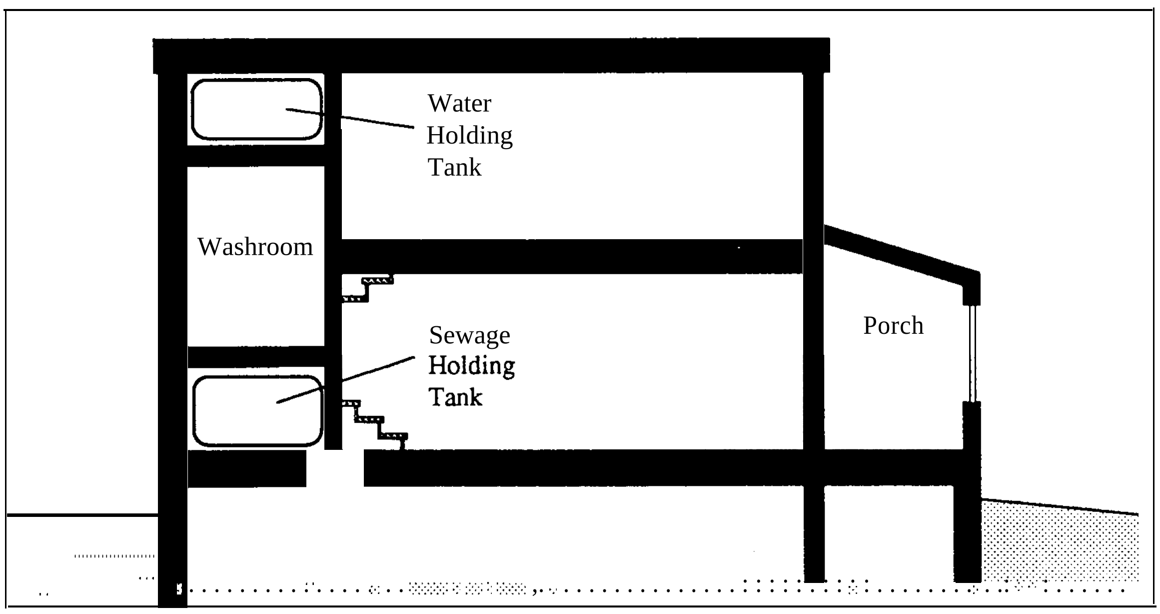
4. It is almost totally self-sufficient, and not vulnerable to interruptions in power supply.

5. Unvented attic.

Split-Level Washroom

Although now, a relatively common feature in some remote and northern communities, the split-level washroom in the Keewatin demonstration models was the first of its kind.

The design allows both the water and septic tanks to be inclosed withing the thermal shell.



DESIGN AND ARCHITECTURAL NOTES

The house was a first in many regards. It was the first to include such a large cold porch. It was the first to put the water storage tank overhead and the bathroom on the half-level so that the sewage tank could be stored below, inside an insulated shell.

The basic premise was to come up with a prefabricated wall section that would allow the house to be put together and closed within four days. The clear span characteristic also enables interior partitions to be placed at will so that the layout can accommodate the needs of the specific occupants to some degree and avoid floor twisting due to frost action.

The second criteria, was that the house remain heated during power failures. Mechanical systems have been kept as simple as possible to reduce maintenance problems.

Things that could changed include:

- wall prefabrication; could platform frame and retain 'bents', and
- foundation to space frame.

BUILDER NOTES

Not hard to build, but the two-storey full-height wall trusses too hard to because of winds and working without a platform. Full span trusses an excellent idea.

Would recommend a platform frame construction, despite the longer construction and closing time. Some thought might be given to going to a stress-skin panel construction.

Plans were a little difficult to read because they were in metric, but most of the material was in imperial.

RESIDENT REVIEW

Overall the house residents have found the house great to live in. There were a few problems to start with; at first the oil tank was stored indoors, but due to the odour, it was moved outside. Also the hrv – one of the first models – was too noisy and as a result turned off frequently. Residents also found that hardboard used on interior difficult to hang things on.

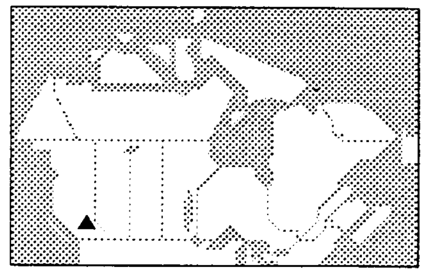
The amount of storage received mixed reactions. Some residents felt that there was more than adequate storage, while others found that there was not enough. Designers should keep in mind that storage, along with other features can be very 'occupant specific', and emphasizes the need for resident input at the design stage, as well as the need to introduce flexibility into the design.

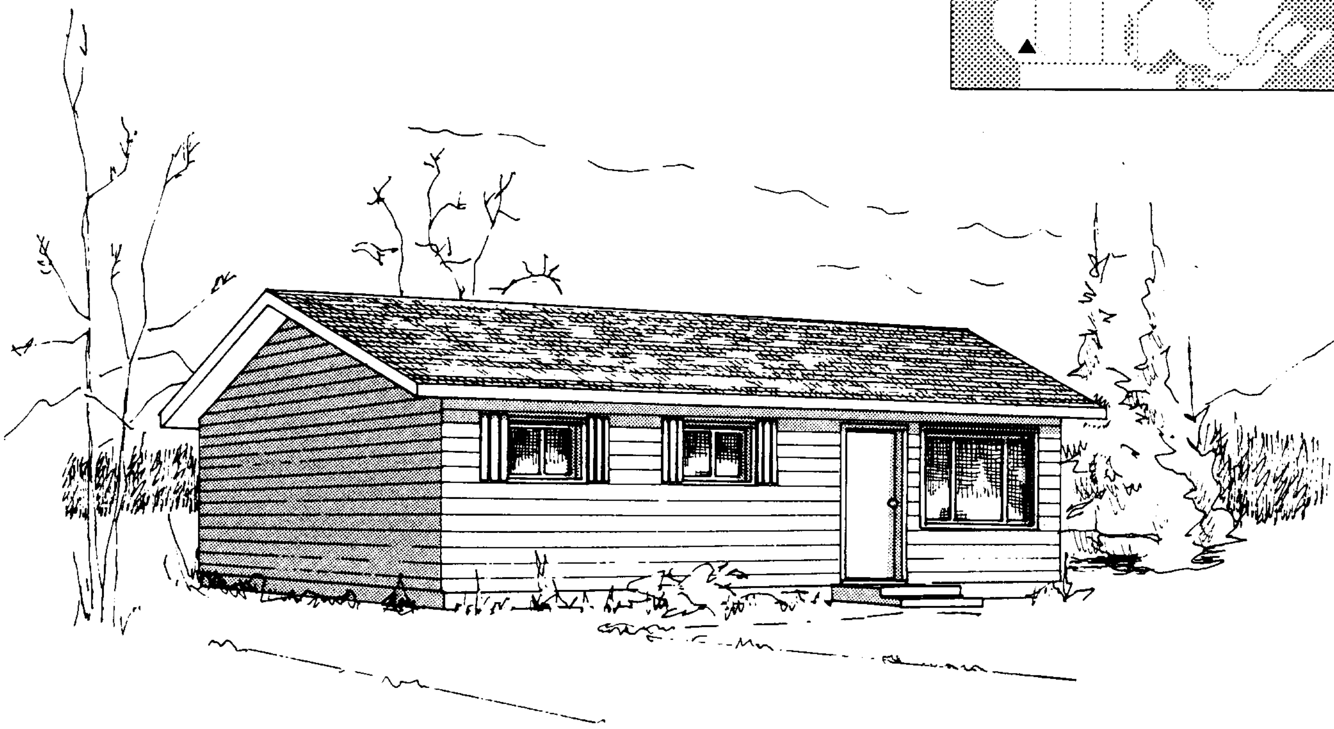
COSTS AND CONTACTS

Six demonstration homes were constructed in 1981 in various communities in the Keewatin District. Costs ranged from $100,000 to $120,000 (including air freight).

For further information contact:
NWTHC District Office
Rankin Inlet, NWT, XOC OGO
(819) 645-2826

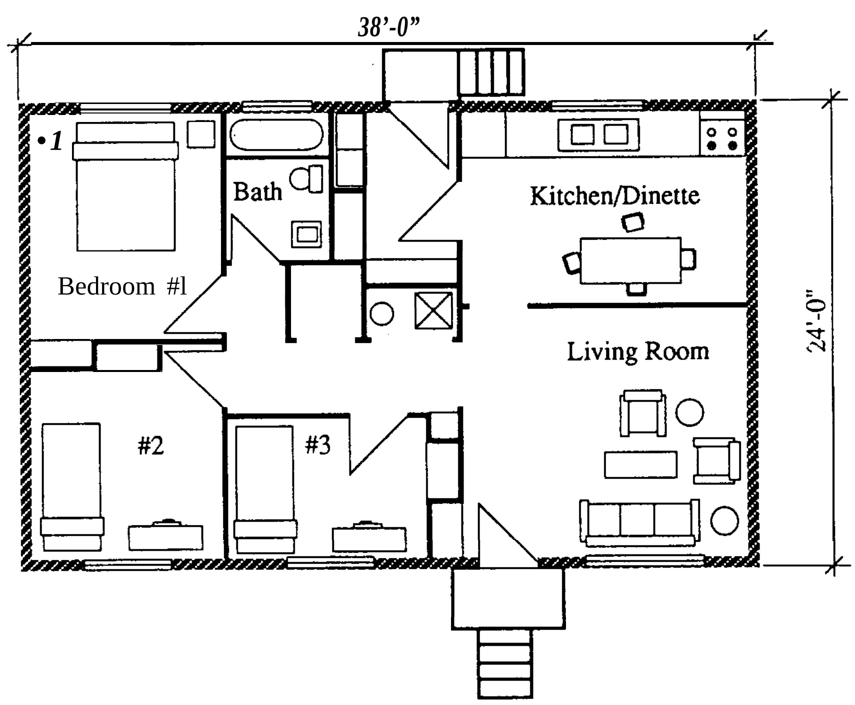
100 MILE HOUSE – B.C.





This is a compact three-bedroom’ bungalow. It is a prefabricated house using a CANO wall system and features a large walk-in storage and utility area.

Dimensions -7.32 m x 11.S9 m (24’ x 38’)
Finished living space -84.81 m^2 (912 sq ft)
Unfinished living space -0



CONSTRUCTION

The house sits on a full PWF crawlspace. Depending on soil conditions and family needs, however, the design can be slightly altered to allow the house to rest on a full basement.

The above-grade walls consist of factory assembled panels with window and door openings already framed. The panel consists of a rigid polystyrene core, with the load-bearing lumber embedded right in the panel.

It is a truss roof, engineered to meet local conditions. However, it is not a high heel truss and no provisions have been made to install additional insulation where the truss meets the exterior walls.

The air-vapour barrier system consists of a polyethylene sheet and caulking which is used to seal seams as well as building components – at the bottom plate around the perimeter of house, for example.

Windows are wood or vinyl fixed and casement and double glazed. Doors are all pre-hung steel.

Thermal Values:
Crawlspace walls - RSI 3.52 (R20)
Above grade walls - RSI 3.52 (R20)
Attic - RSI 7.04 (R40)

OPERATION

The houses are designed to use both a wood space heater and electric baseboard. Natural air movement provides heat distribution. The open floor plan also promotes distribution.

The ventilation system consists of exhaust fans in the kitchen and bathroom, as well as operable windows.

Water supply is either well, or on a municipal main where appropriate. Sewage disposal is handled with a sceptic system.

PERFORMANCE

No performance information is available. The relatively low insulation levels suggest that this unit is more suited to remote and northern areas with less extreme cold temperatures than the Artic.

However, the unit is compact, with a relatively open layout, and is reported to be easy to heat. Aditional insulation could easily be added to the interior or exterior of the above-grade walls.

FEATURES

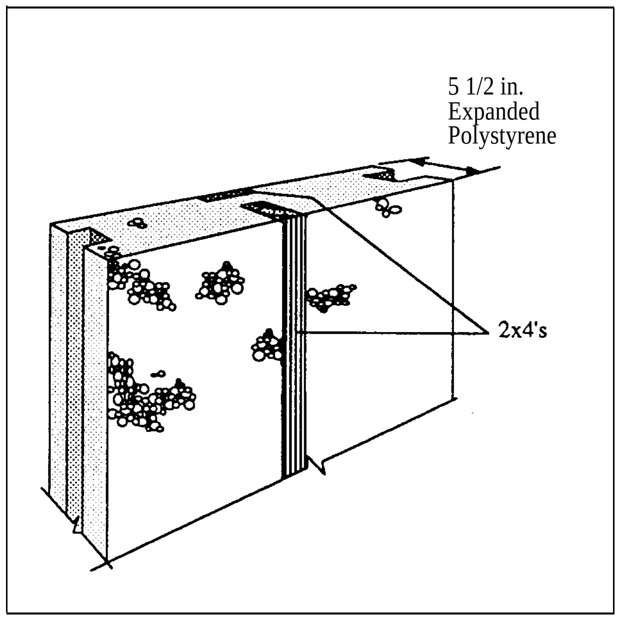
This is as straightforward as houses come. However, in terms of northern and remote housing, that can be a plus. It is fast and relatively easy to erect. Other features include:

1. Open plan, which helps heat distribution.
2. Insulation levels can be be upgraded.
3. The benefits of a modular wall system.

Prefabricated Wall – CANO system

Prefabricated housing refers to factory-cut and marked wall (and roof) sections. The pieces are then shipped to the site and put together much like a jigsaw puzzle.

There are a lot of different prefabricated wall systems available for housing. Most are custom fabricated to plans submitted by the builder, and come complete with rough openings for windows and doors. The systems are characterized by minimized framing, which results in reduced thermal bridging from the interior to the exterior. Secondly, the systems have factory-installed insulation, which minimizes gaps in the insulation and reduces convective air movement within the exterior shell of the building.



The CANO wall employs a solid core of expanded polystyrene insulation bonded to studs which are staggered throughout the wall assembly. The staggered studs allow nailing surfaces on the interior and exterior without thermal bridging.

Erection of the walls is similar to standard platform framing. The wall sections are laid out on the floor deck and lifted into position. Exterior siding follows common practice. .

On the interior 2 x 3 strapping can be added to act as a chase for electrical and additional space for insulation. Or a channel can be routed in the panel for wiring. In either case it is still worthwhile to install a polyethylene (air) vapour barrier, even where not specified.

“DESIGN AND ARCHITECTURAL NOTES

These houses were built under CMHC's Rural and Native Housing Demonstration Program. Under this program, residents are supplied with a materials package, but must own their own land.

Five units were built within 100 kilometers of Bridge Lake, B.C. In this particular project, while clients were required to fall within a certain income bracket, they had to own the land on which the houses were to be built.

The design is good, small and compact. While there is nothing ‘architecturally’ overwhelming, the house makes good use of space and appears to have a reasonable amount of storage space with the large utility room. Using the basement version where soils permit would increase storage space.

BUILDER NOTES

It is one of several standard designs produced by Spruce Capital Homes. It is a simple unit, easy to erect, and does not require a great deal of construction background. Basically, one knowledgeable construction supervisor and three strong backs can have this unit up in only a few days.

Not only does a kit system reduce on-site labour costs and speed erection, but it allows for a higher level of quality in the structure because the modules are built in a factory “controlled” situation. (On the other hand, less local labour and materials are used). They make a great deal of sense in extremely remote areas with limited construction seasons.

It can also be easily be upgraded by using intenor strapping, or offset 2 x 3 walls. Perhaps its greatest feature is that it can be added onto at a later date, when more money is available.

RESIDENT REVIEW

While no interview could be arranged, several points concerning management and client relations did come out.

Firstly, clients should be made full aware of the amount of work that is required in putting together a house. This is especially true in areas where certain times of the year are given over to pursuits such as hunting, trapping, and fuel gathering.

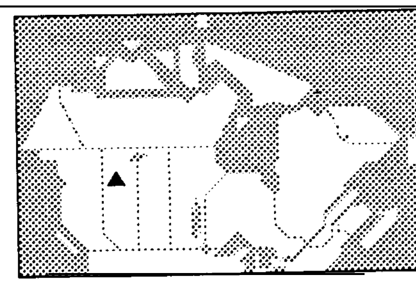
Obviously it is essential that the supervisor be well versed in construction issues. However, it is just as important that they possess interpersonal skills, especially when dealing with unskilled clients.

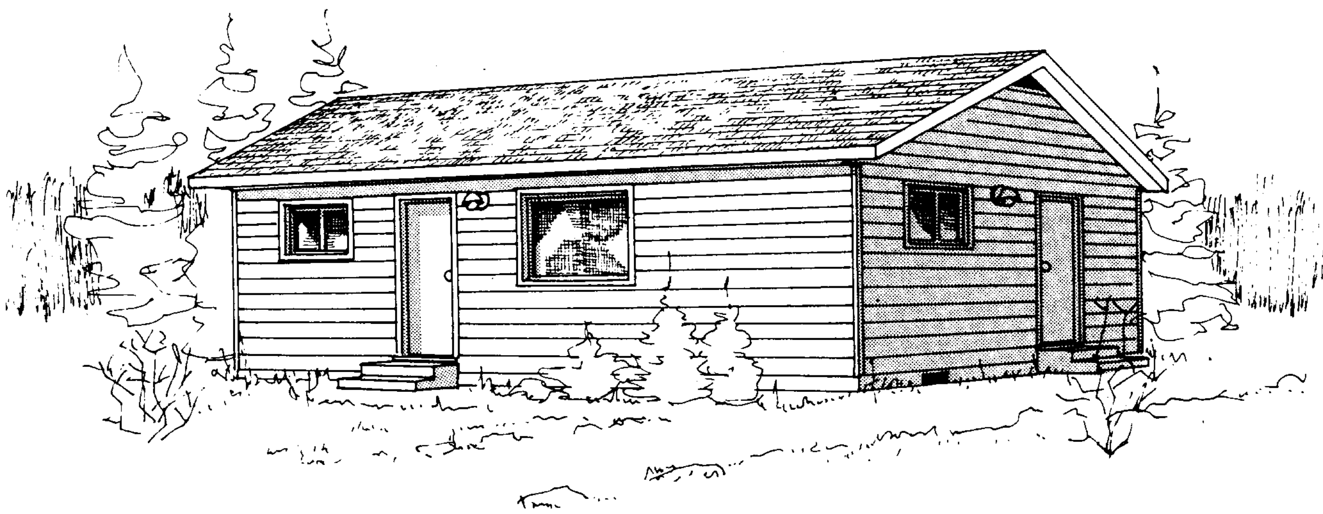
COSTS AND CONTACTS

The average costs of the units in 1986 dollars was approximately $40,000. For further information contact:

Canada Mortgage and Housing Corporation
District Office, 300-299 Victoria St.,
Prince George, B. C., V215B8

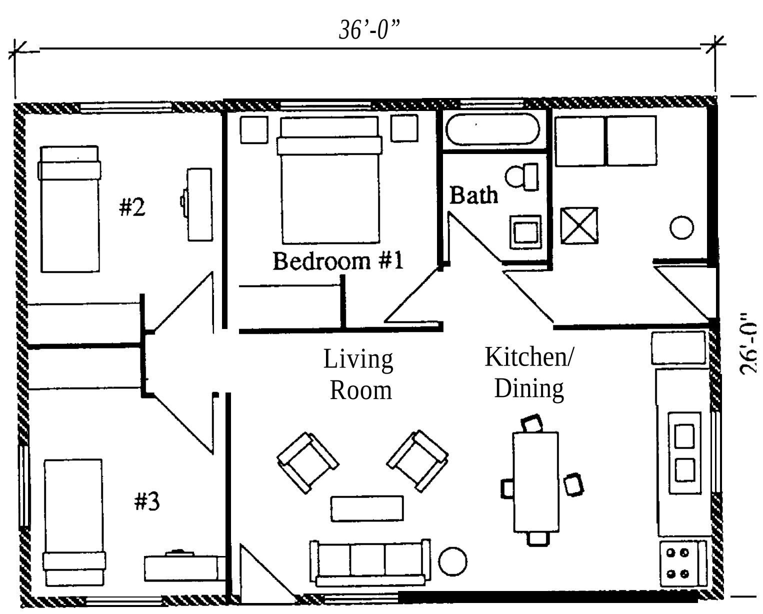
CONKLIN ALBERTA





A small three-bedroom bungalow. The house was designed by the Alberta Rural Housing Corporation for use in extremely remote communites. Like the 100 Mile house, this is a very simple structure: well insulated, and very easy and inexpensive to build.

Dimensions -7.93 m x 10.98 m (26' x 36')
Finished living space – 87.04 m^2 (936 sq ft)
Unfinished living space – O



CONSTRUCTION

The house sits on a 38 x 140 mm (2x 6) preserved wood foundation wall which rests on an 190 x 470 mm (8 x 20) continuous concrete beam.

The exterior walls are a prefabricated unit called PlastiSpan system. Similar to the CANO wall, the studs in this instance stick out – on the inside – one and a half inches. This space provides both an electrical chase and an additional cavity for insulation.

Windows are a good quality vinyl slider with double glazing. The doors are all steel insulated.

Thermal Values:
Crawlspace walls - RSI 3.52 (R20)
Above-grade walls – RSI 4.2 (R24)
Attic - RSI 7.04 (R40)

OPERATION

These houses are designed to be totally heated by wood. Since the majority of the communities are off grid, no back-up system is provided.

Heat distribution is primarily by natural convection. Any mechanical aids, such as fans, have to be provided by the clients.

Ventilation is all supplied by bathroom fans and windows.

Water is hauled in by hand and stored in barrels.

While the plumbing is roughed in, none of the units has indoor facilities. Sewage waste is handled either with outdoor facilities, or by a honey bucket system.

PERFORMANCE

No performance information available.

FEATURES

While not superinsulated structures, the design and concept have much to recommend themselves to northern planners. For example:

1. They are simple units, and by consequence easy to build and quick to erect.

2. The Alberta Rural Housing Corporation has a wide range of plans to choose from; from two-bedroom to four- bedroom models. Within each of those categories, there is a variety of floor plan layouts to choose from.

3. The open living area helps with the heat distribution, and gives the house a larger feeling.

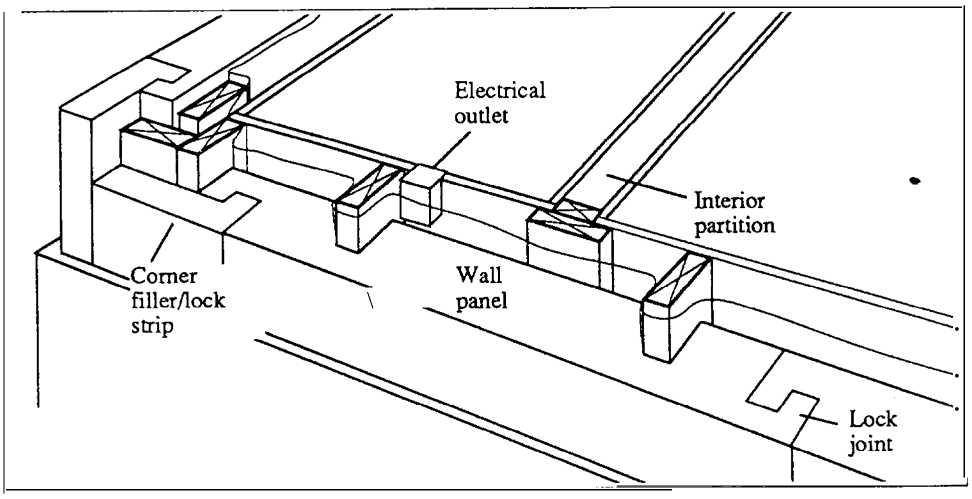
4. The house features an exterior attic hatch.

Prefabricated Wall – PlastiSpan system

Similar to the CANO wall in the 100 Mile House, the 'PlastiSpan Thermal Lock Wall Insulation' is a prefabricated factory built system. The panels are eight feet in length and come in two thicknesses – 3 1/2" (R 13.1), and 5 1/2" (R 20.6).

The panels come with interlocking joints and pre-cut grooves for the studs.

Putting the panels together requires few changes from conventional platform framing. The insulation is laid down and locked together. The studs and bottom and top plate are then fitted into place and nailed together.



Doors and windows are framed in a conventional manner. Battens placed on the exterior of the panels provide stability for the system while holding the panels to the studs.

The battens also provide a base for the exterior finish.

On the intenor, the studs project 2" beyond the face of the insulation. This cavity allows room for wiring and mechanical services. It also provides a space for an additional R 8 worth of batt insulation.

The recessed studs also mean that no wood connects the intenor of the house to the exterior environment. In other words, there is no thermal bridging.

DESIGN AND ARCHITECTURAL NOTES

This design is one of several available under the Alberta Rural Housing Corporation (RHC). RCH has been in existence since 1978 and provides housing packages and construction supervision for clients within certain income brackets.

During its first years of operation, log construction was used extensively. However, with completion time taking as long as two years, more conventional forms of construction are now used. "We're now starting to get away from stick framed designs to simplify shipping and erection time, says Ken Mathews of the RCH. " This unit pictured here is one of our first prefabricated units.

"We have designed the layout with client input, trying to respond to their needs in terms of size and space and layout. We also try to simplify the construction process as much as possible. It's a kind of bare bones approach."

Because of this bare bones approach, energy-efficiency has taken a back seat to other concerns. However, the basic house can easily be upgraded, and the PlastiSpan system appears to provide a relatively good air seal.

BUILDER NOTES

These units are very easy to build. Most of them are owner or band built with the aid of a skilled supervisor.

Normal construction involves 38x 140 mm (2 x 6) exterior stud walls which means that there is less cost, because there are fewer materials, and it also means that the houses go up very quickly, which is important when the construction season isn't that long.

It also means that the houses are not difficult to build which is our other aim. Anyone with a little guidance and assistance can erect one.

Despite the fact that it is a relatively simple house, a lot can be done to it if you have additional money. Cold porches, for example, can be added on, or the insulation levels can be increased if you wanted to use the unit in a community even farther north.

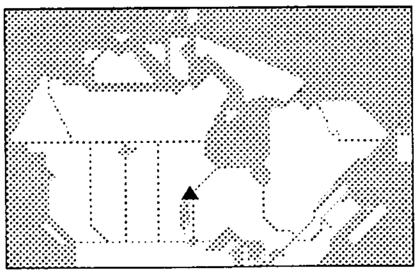
COSTS AND CONTACTS

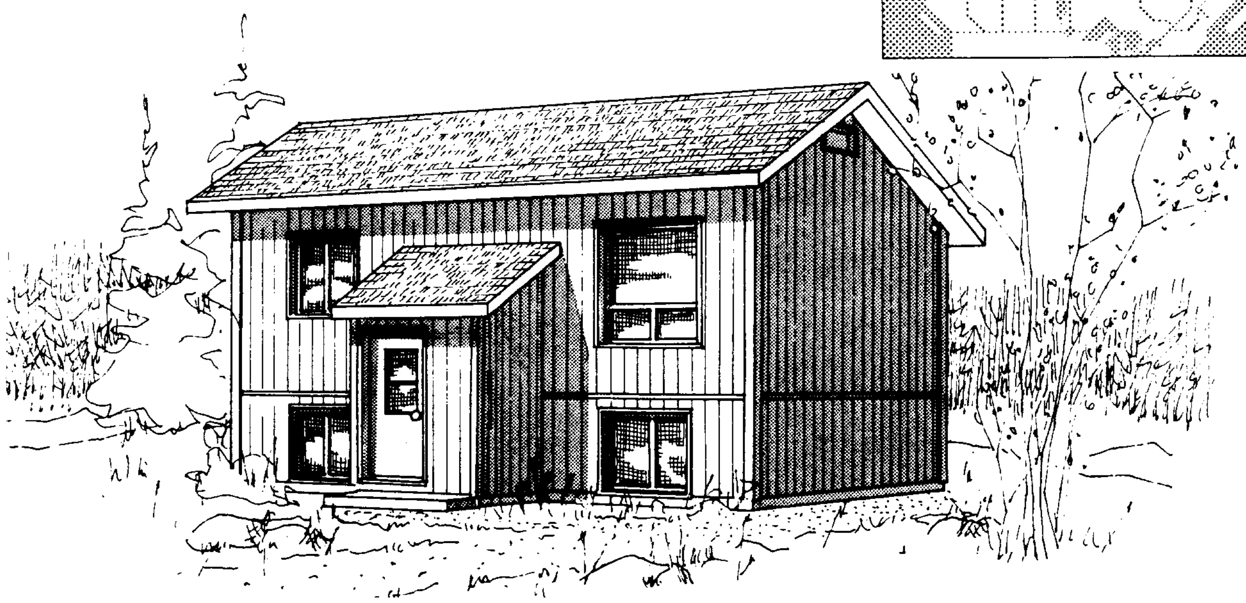
The materials package including delivery was under $20,000.

Labour is supplied by the client under a sweat equity agreement.

For further information contact:
Reagan McCulloch
Alberta Rural Home Assistance Program
Slave Lake, Alberta
(403) 849-7250

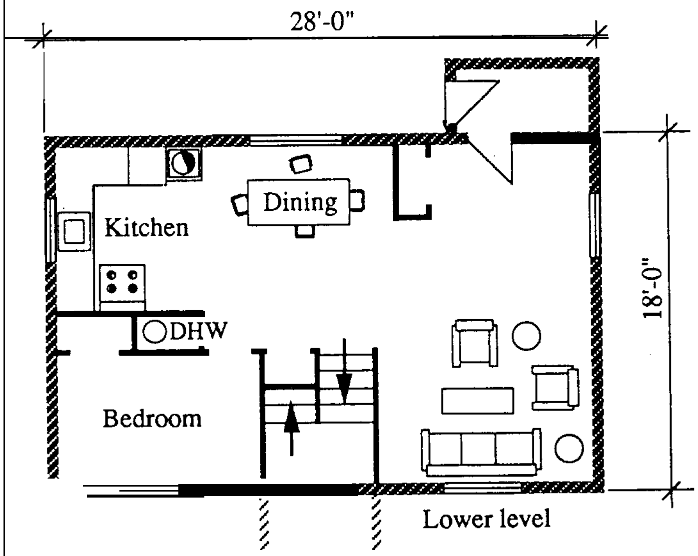
ISLAND LAKE – MANITOBA

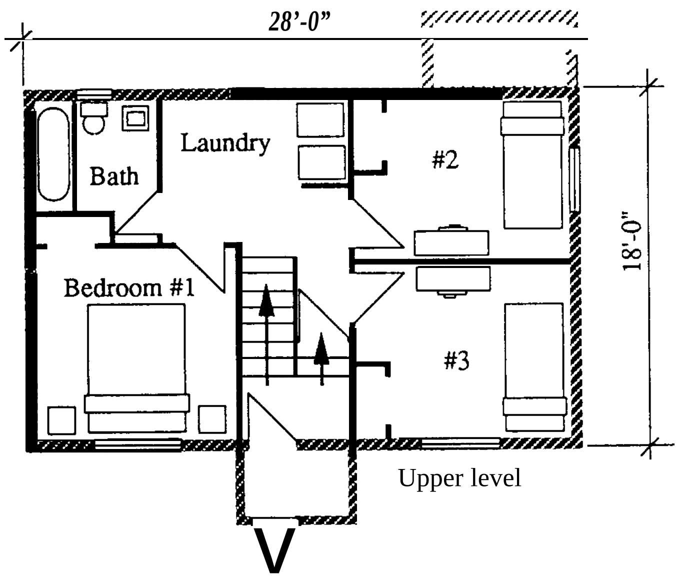




This is a four-bedroom hi-level developed for remote Northern Manitoba communities with limited electrical and other services. The hi-level design allows excellent separation between public and private areas; although there is one bedroom (or optional storage area) located on the first floor for an elderly person or guest.

Dimensions -5.49 m x 8..54 m (18' x 28')
Finished living space -93.74 m^2 (1008 sq ft)
Unfinished living space – O
Porch area -5.11 m^2 (55 sq ft)





CONSTRUCTION

The foundation is 38 X 140 mm (2 x 6) PWF studs on a 38 x 140 mm (2 x 6) PWF wood sleeper floor. The exterior is sheeted with plywood which has been caulked and sealed and then wrapped with 10 mil polyethylene for dampproofing. The poly in turn is covered with buffalo-board to protect it during backfilling. On the intenor a 6 mil polyethylene vapour barrier is installed followed by 38 x 38 mm (2x 2) strapping for extra insulation and finished off with drywall.

The above-grade walls are 2 x 6 studs with 2 x 2 strapping on the interior. The exterior is covered with a Tyvek air barrier and sided with vertical 'ranchwall' panels.

The interior is finished off similar to the foundation walls.

The roof is raised heel truss joists and insulated with R 40 worth of glass fibre.

Windows are triple glazed; and are casement and awning combination.

Thermal Values:
Foundation - RSI 4.9 (R28)
Above-grade walls – RSI 4.9 (R28)
Attic – RSI 7.04 (R40)

OPERATION

Most of the communities are so isolated that there are no roads, and even diesel fuel for generators is non-existent. Consequently, the houses are built to *run in a* self-sufficient manner.

The only heat source for the building is a woodstove with an exterior combustion air intake. The combustion air intake is not ducted directly to the stove, but supplies the entire house, though it relies on the heat from the stove behind the heat shield to create the pressure to draw more or less air.

Sewage is a honeybucket system, and the water is carried by hand and stored in 200 gallon tanks that sit on the porch.

PERFORMANCE

Results from the monitoring program are not yet available. On a more informal level, wood consumption is down by at least one-half when compared with other residences in the community.

Airtightness tests performed on the houses show them to be very tight. This is the result of both the air barrier system and careful construction.

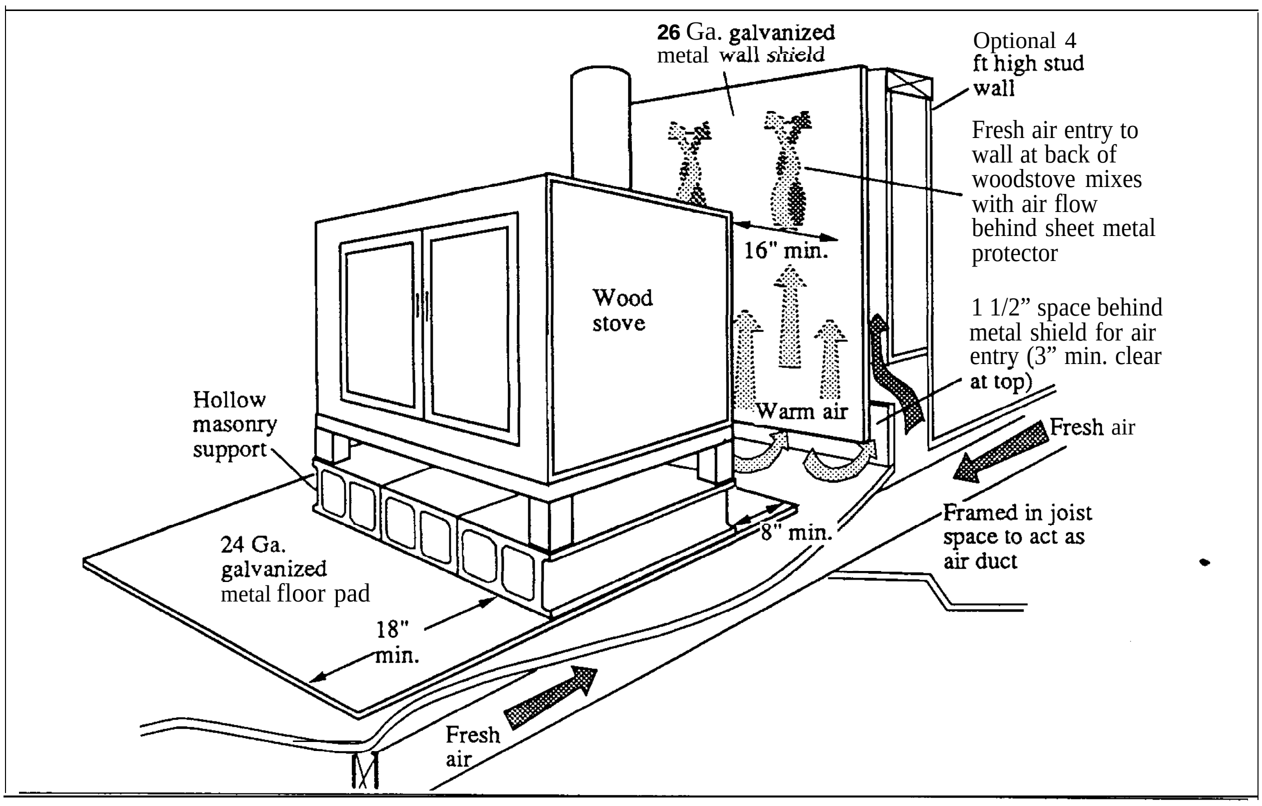
FEATURES

There are several features that make this house of particular interest for those involved in the design and selection of houses for extremely remote areas.

1. High levels of energy-efficiency.
2. Extremely self-contained.
3. Lots of room, despite the relatively small size of the foundation foot print.
4. Unique passive ventilation system.

Passive Ventilation System

The ventilation system used in this hi-level adds a unique twist to the 'conventional' passive ventilation system. unique twist to a conventional passive system, by using the woodstove to preheat the incoming air in an indirect manner.



A strict passive ventilation system does not use any electrically-powered equipment when exchanging fresh air for stale air. In its most simplistic form, this means simply opening the window. One of the main drawbacks of a conventional passive ventilation system is that the fresh air when it enters the house has not been preheated. The ILTC design adds a The fresh air enters at the lower level through the joist header and travels through an insulated joist space that comes out behind the metal wall heat sheild by the woodstove. The fresh air mixes with the heated air flow behind the shield, and is then dispersed through the house.

DESIGN AND ARCHITECTURAL NOTES

Originally, six different models were designed for the Island Lake Tribal Council, however, the hi-levels are the ones that have become extremely popular, and in some communities are the only ones that are being built. The design is ideal for larger family units.

The 5.49 m x 8.54 m (18 x 28) model is the most common. It gives the largest house size for the smallest footprint.

The original designs were prepared in direct consultation with the communities involved.

The plan is relatively open. The heating source is located on the lower level to allow warm air to rise and return air grilles are located at various points around the perimeter of the upper floor.

It is imperative that outside shelters be provialed around entrances in these communities to act as wind blocks and to provide extra storage space. Most of these communities are not serviced, so the lavatories must be located right next to an exit to facilitate disposal. "

BUILDER NOTES

The houses were built totally by band members. They're not hard to build but require the teaching and upgrading of a lot of skills. In particular, the band members had never seen a hi-level before. The foundations were all new to them. The concept of energy efficiency – and therefore energy efficient detailing – was all new as well. The ILTC has developed an intensive four year training course that combines class room and hands-on instruction to teach and upgrade the skills required to build quality housing.

Materials all had to be trucked in, so several changes were made to the plans on the site to use more appropriate materials. For example, the original design called for concrete foundations and floors; these were changed to PWF. The plans have now been finalized to reflect these changes.

RESIDENT REVIEW

"Overall, a great house. It's a pretty basic unit that is efficient, reliable, and keeps the heat in. The house is easy to maintain, and I go through about half as much wood as before – up to this point in the winter it was between two and two and a half cords, compared to five or six from previous years.

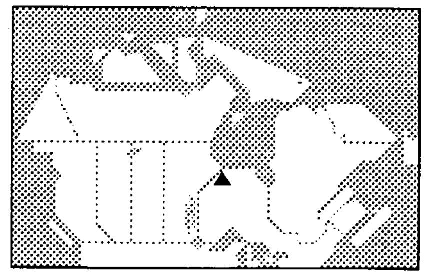
Lots of room; especially with the downstairs, so that putting up visitors is not a problem. Also, it's much cooler down there in the summer, so when it gets too hot we move down there ourselves. "

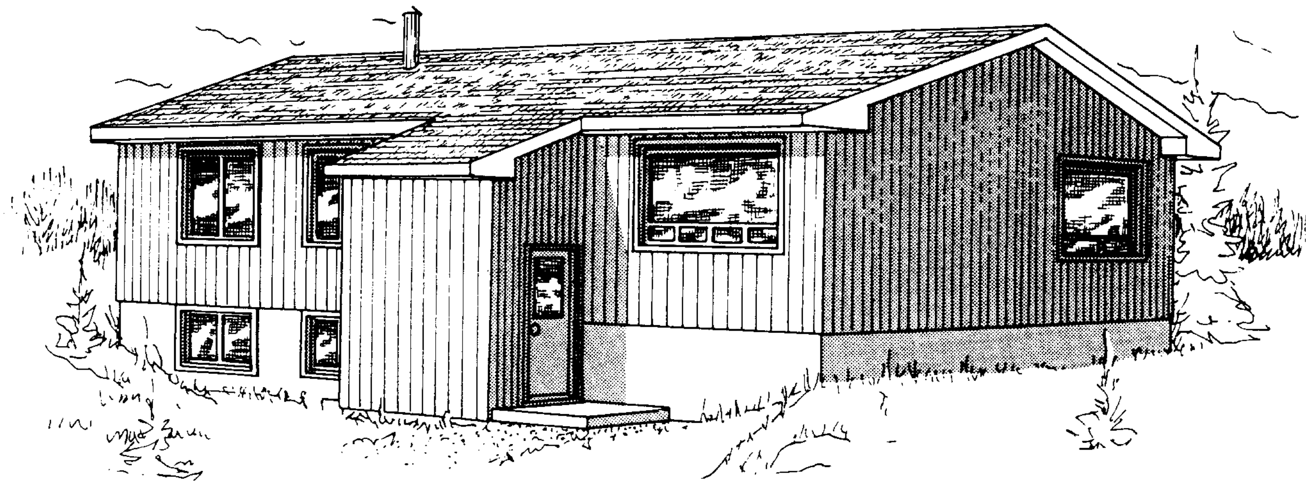
COSTS AND CONTACTS

The average cost of the 18 x 28 hi-level is $43,000 in 1987 dollars. This includes $23,000 for materials and freight, and $16,000 for trades. For further information contact:

Pat Done
Island Lake Tribal Council Inc.
315-267 Edmonton St.
Winnipeg Manitoba, R3C 1 S2 (204) 947-0201

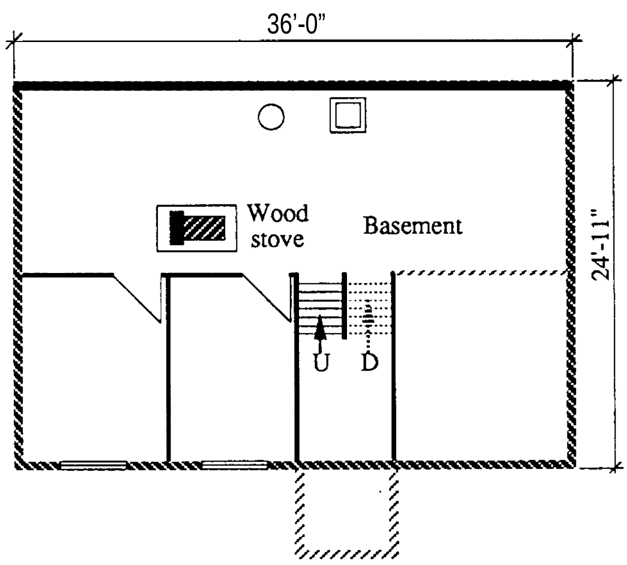
PEAWANUCK - ONTARIO

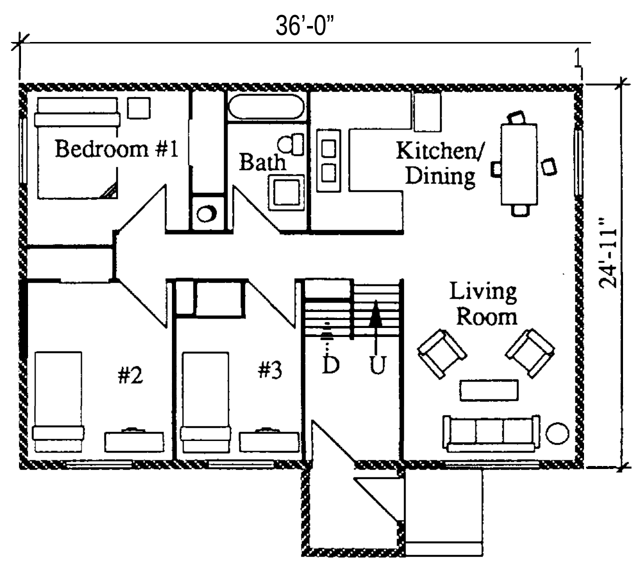




This is a three-bedroom bungalow which was designed and built in 1986. It is an energy-efficient house designed to be heated by a woodstove located in the unfinished basement.

Dimensions -7.32 m x 10.97 m (24' x 36')
Finished living area -80.27 m² (864 sq ft)
Unfinished living area -80.27 m² (864 sq ft)





CONSTRUCTION

The house uses a preserved wood foundation. The exterior walls rest on pad footings and the basement floor is supported by sleepers resting on gravel. Below-grade walls are 38 x 140 mm (2x 6) studs with fibreglass insulation. Above- grade walls are 38x 140 mm (2 x 6) studs with 38 x 64 mm (2 x 3) interior strapping, fibreglass insulation and a Tyvek weather barrier. A continuous polyethylene air and vapour barrier is caulked at all seams.

On the above-grade walls the polyethylene is installed between the studs and the strapping.

Windows were triple glazed clad wood sliders.

Thermal Values:
Below-grade floor - RSI 0.9 (R5)
Below-grade walls - RSI 3.5 (R20)
Above-grade walls - RSI 5.3 (R30)
Attic – RSI 7 (R 40)

OPERATION

The heating and ventilation systems are identical to that of the Windigo House with the exception that the woodstove is located in the centre of the unfinished basement. Heat is distributed to the living area of the house through the floor and the open stairway.

The house is designed for communities where water and sewage hookups are available.

PERFORMANCE

The energy performance of the homes in Peawanuck was monitored as part of a study to determine the most appropriate woodstoves for remote communities.

The study reported that the houses could be heated comfortably with two to three cords of softwood, depending on the type of stove used. Heat distribution through the living area was uniform and even the smaller stoves were able to keep the house warm during the coldest days of the winter. This is a great improvement over the performance of the houses in the community 's old townsite of Winisk, both in terms of the amount of wood used and the comfort of the houses. As Chief George Hunter remarked, "In the old houses in Winisk the stove had to look after the house, but in Peawanuck, the house looks after the stove."

Concerning the ventilation system, the study reported that humidity levels were comfortable, there was no problem with condensation on windows and air quality was good. The air was fresh and without lingering odours, even in homes where fish and game are frequently cleaned indoors.

FEATURES

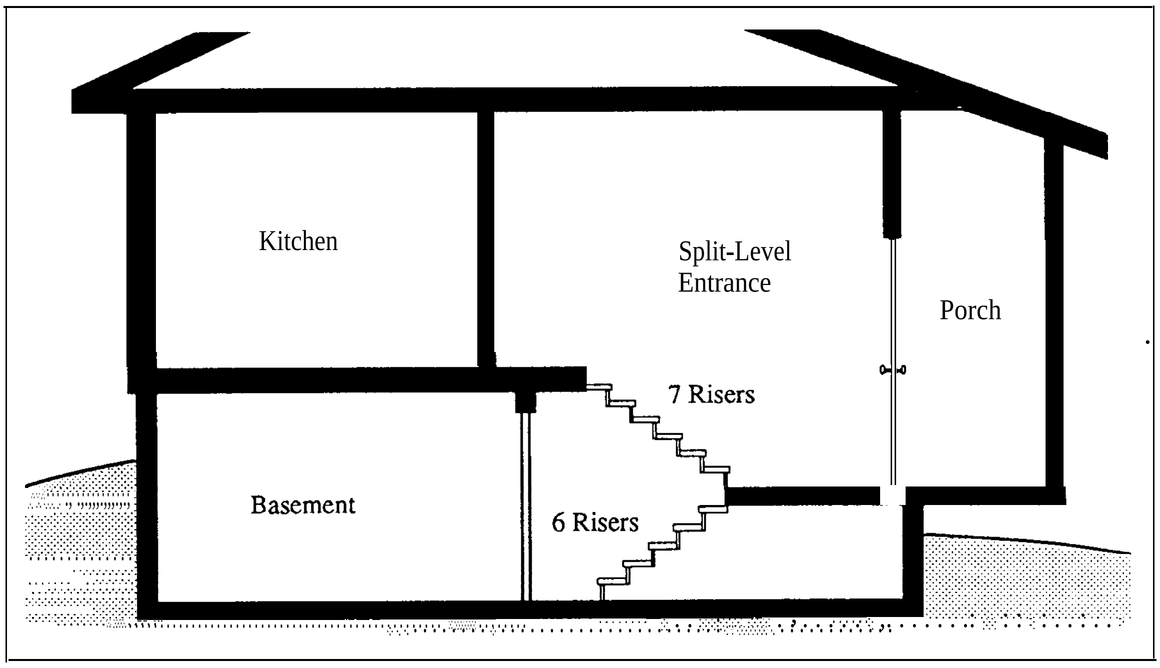
This design includes a number of features that are especially suitable for northern or remote housing:

1. Passive solar features.
2. Split-level entrance.
3. Wood heating.
4. Site-built heat exchanger (similar to Windigo).

Split-Level Entrance

The split-level entrance is a design feature that is especially suitable to northern conditions. It provides a vestibule that is separated from the living area and it gives direct access to the unfinished basement. This is an important feature where the basement will likely be used as a work area for repairing equipment and cleaning game and fish.

The split-level entrance is also an important part of the house air distribution system. Since the entry is open to the basement, cold air from the front door will fall into the basement, setting up a natural air current. Warm air from the woodstove will circulate to the upstairs by way of floor grilles and cool air from upstairs returns through the open stairway.



DESIGN AND ARCHITECTURAL NOTES

This design was developed for the new townsite of Peawanuck. Design consultations were underway with the Council as part of the planned community move when a disastrous flood destroyed the old townsite of Winisk.

As a result, the design and construction process was accelerated; houses had to be built for the entire community in a few months.

The design requirements were that the house be energy efficient, heated with wood, incorporate passive solar features and include a site built heat exchanger. Because of the hurry to build the houses, the design had to be simple and easy to build. While the design meets these requirements, future versions might be improved if the house were larger, and a window and an entrance were added to the kitchen.

BUILDER NOTES

The new community of Peawanuck was built largely by Band members with help from native construction workers from several nearby communities. In order to meet the deadline of housing the community before winter, fifteen of the 43 buildings were contracted to an outside builder. A specialist was hired to coordinate the project and five carpenters were hired from outside the community to head up the crews. As an additional time-saving measure, the construction was done on an assembly-line basis. Crews moved from house to house, with each crew building one particular section of the house.

The houses were easy to build and the energy-efficient features such as tighter construction posed no problems.

RESIDENT REVIEW

The community's houses at the old townsite of Winisk were bungalows built on stilts over an open crawlspace. They were subject to severe heaving. They were not energy efficient or comfortable and had virtually no storage space.

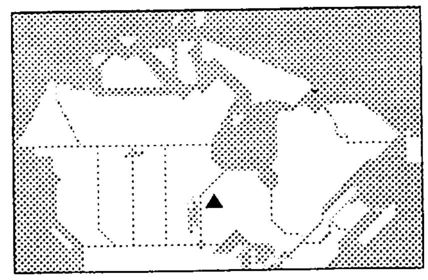
In comparison, the homes at the new townsite of Peawanuck are a great improvement. They are comfortable and easy to heat, the air quality is good, and there are no problems with condensation or frosting of windows. The new townsite is located on limestone and gravel, making the full basement possible without problems of frost heaving. The basement space is a welcome addition. Families are using it for storage or workspace and in some homes the basement is being finished to use as extra bedrooms or a family room.

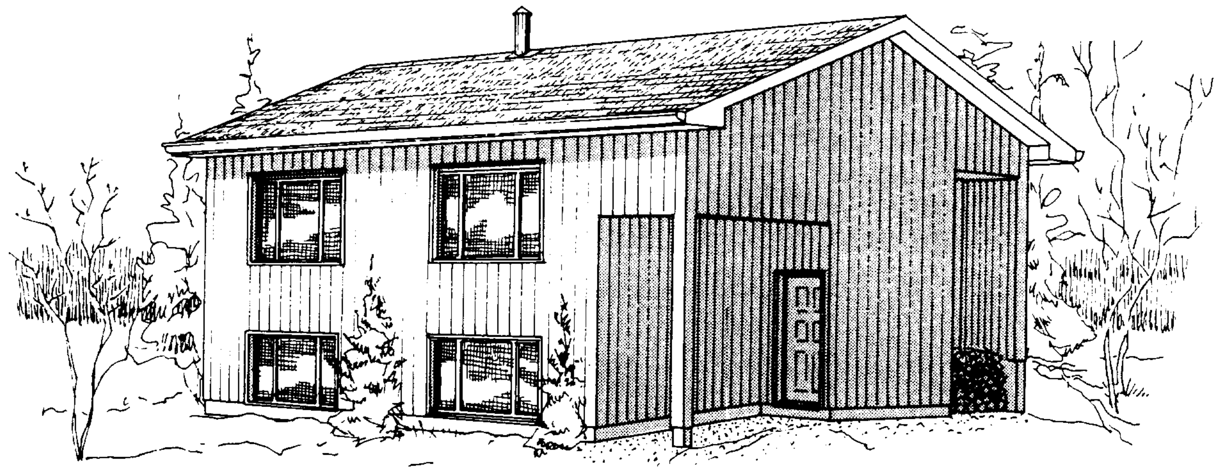
COSTS AND CONTACTS

The costs for these units worked about to be approximately $104,600 in 1986. The costs were abnormally high because of the materials had to be shipped to the site by helicopter ($43,907).

For further information contact:
Mr. Jeremy Jenkins
RR#3
Caledon East, Ontario, LON lEO
(416) 880-1048

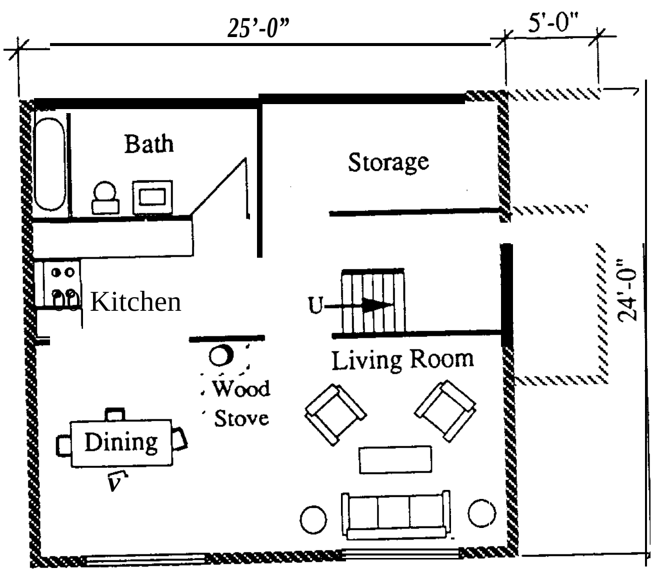
WINDIGO – ONTARIO



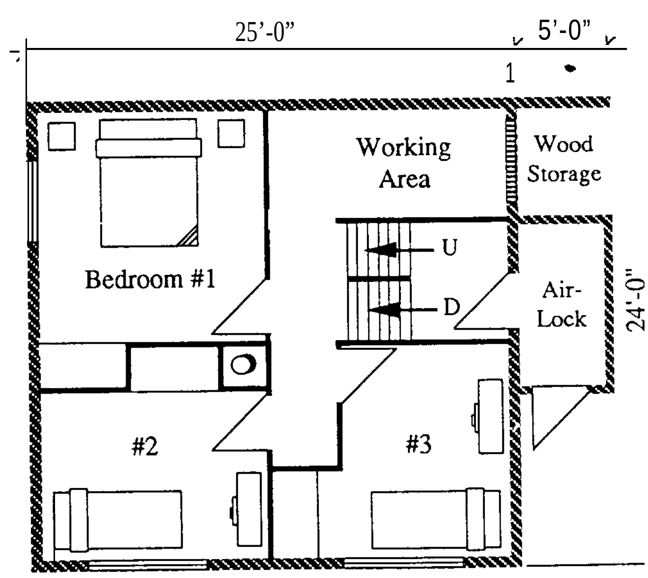


This is a small three-bedroom home designed for wood heating. It is an energy-efficient design featuring passive solar gain, airtight construction, and controlled ventilation. The design was originally developed by Jeremy Jenkins. This version was adapted by Keewatin-Aski Engineers and a demonstration house was built by menders of the Sachigo Lake Band in 1987.

Dimensions -7.32 m x 7.92 m (24' x 26')
Finished living area -115.94 m^2 (1248 sq ft)
Unfinished living area -0



Lower level



Upper level

CONSTRUCTION

The house is built on a preserved wood foundation. The below grade walls are 38 x 190 mm studs (2 x 8) with the stud spaces filled with fibreglass insulation. Rigid insulation was applied on the exterior of the foundation walls. An alternative foundation design shows 38 x 140 mm (2 x 6) stud walls with 25.4 mm (l") of exterior rigid insulation and 38 x 64 mm (2x 3) strapping on the interior.

Above-grade walls are 38x 140 rnrn (2 x 6) construction with 12.6 mm (1/2") of semi-rigid insulation applied on the exterior and 38 x 64 mm (2 x 3) strapping on the interior.

The polyethylene air and vapour barrier is recessed in the wall – between the strapping and the studs.

The windows are Weathershield triple glazed units with Low-E coating.

Thermal Values:
Below-grade walls: RSI 4.9 (R28)
Above-grade walls: RSI 4.9 (R28)
Attic: RSI 10.6 (R60)

OPERATION

The house was designed to be heated with an airtight woodstove using natural air movement to distribute the heat. The ventilation system consists of exhaust fans in the kitchen and bathroom, an air intake fan and a site-built heat exchanger. The air intake fan can be wired to a humidistat or operated manually. Even when the fan is not running, air can be drawn past the fan chamber. With this safety feature, whenever fresh air is needed because the exhaust fans or a stove is being used, it will be drawn into the home automatically.

The fresh air intake is positioned so that the incoming air is blown down over the woodstove; this serves to provide combustion air as required and to mix cool incoming air with warmer house air.

The main floor of the house is an open plan to promote air circulation. Air is circulated to the bedrooms on the second floor through the open staircase and through floor grilles along the exterior walls of the bedrooms.

PERFORMANCE

A monitoring report on this project is due out shortly. Preliminary data suggests that for the 1988 heating season (October – Jauary), 1.5 cords of wood was used to heat this house, compared to 3 cords for a conventionally constructed house of similar size in the community.

FEATURES

This home is a good example of northern housing in four main ways.

1. It is designed to be energy efficient.

2. It is designed for wood space heating.

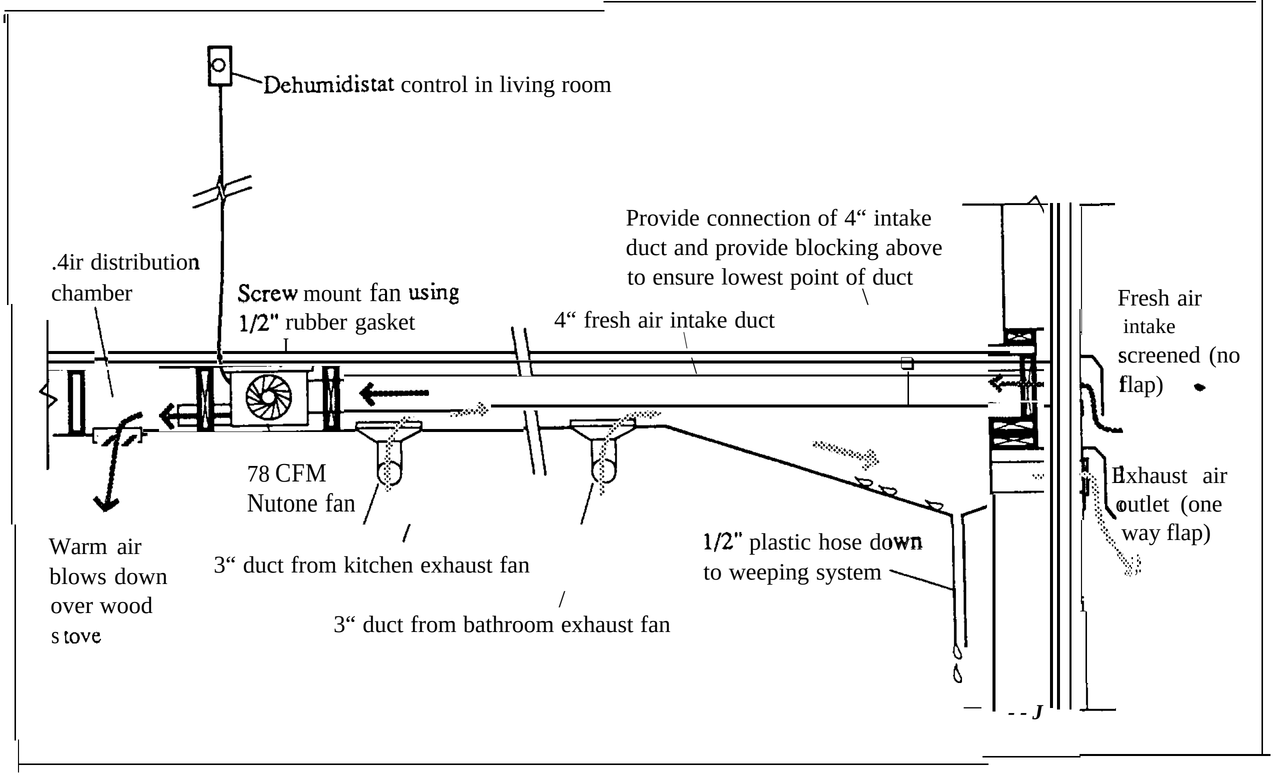
3. It includes a controlled ventilation system that works with a site built air exchanger.

4. It was designed to include all the desired features in the smallest space possible.

Heating and Ventilation

Of these features, perhaps the most unique are the heating and ventilation systems. These systems have fewer mechanical parts, built-in safety features, and they are relatively simple to install. However, while they appear to work, no rigorous testing has been conducted on this ventilation system.

The air intake pipe runs through this air chamber and the exhaust fans for the kitchen and bathroom vent into it. In this way the exhaust air serves to prewarm the incoming air, reducing energy requirements.



The site built heat exchanger consists of an air chamber created by installing a metal joist liner in the joist space.

Also, by cooling the exhaust air, frost build-up is reduced.

DESIGN AND ARCHITECTURAL NOTES

This design evolved from Jeremy Jenkins' work in Peawanuk and the community's experience there. The Peawanuk houses were designed for wood heating from a stove located in an unfinished basement. Owing to the tight construction schedule, people had to live in the basement of these houses while the living areas on the upper floor were finished. "Many people expressed how comfortable it was living in this manner, which was essentially in an open space surrounding the central woo stove. "

Later, Jenkins followed through with that concept, designing a split-level home with an open plan kitchen, living and dining area surrounding a woodstove on the basement level and bedrooms above.

Other successful features of the Peawanuk house, such as the energy-efficient construction, the split-level entry, the controlled ventilation system and the site built heat exchanger, were also incorporated in the design.

For the Windigo House, Keewatin Aski Engineers adapted the Jenkins design. They provialed a secondary exit from the upper floor and more separation between the kitchen and dining areas. In addition, the Keewatin Aski design is somewhat smaller than the original design.

BUILDER NOTES

This home was built by members of the local community with technical advice and some site supervision provided by a technical coordinator from the design firm, Keewatin Aski Engineering. Members of the construction crew were all experienced builders and they were quite interested in the low-energy building techniques. The technical coordinator provided lectures, video and slide presentations on low-energy building during scheduled coffee breaks on site.

RESIDENT REVIEW

Housing at Sachigo Lake is administered by the Band Council. A 1984 study on options for the Windigo Communities identified new energy-efficient housing as one of the community priorities. The Keewatin House was one of the demonstration homes proposed in the stud y.

On the positive side the house is easy to heat and comfortable, the rooms are large enough and there is plenty of storage space. On the other hand, the two storey house appears out of place in a community of bungalows.

COSTS AND CONTACTS

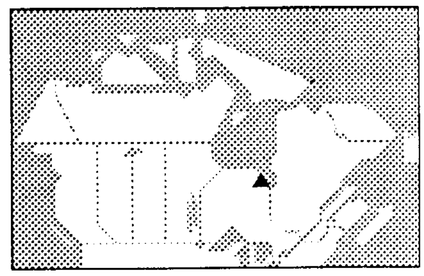
The total cost for this unit was $61,774 in 1984 dollars.

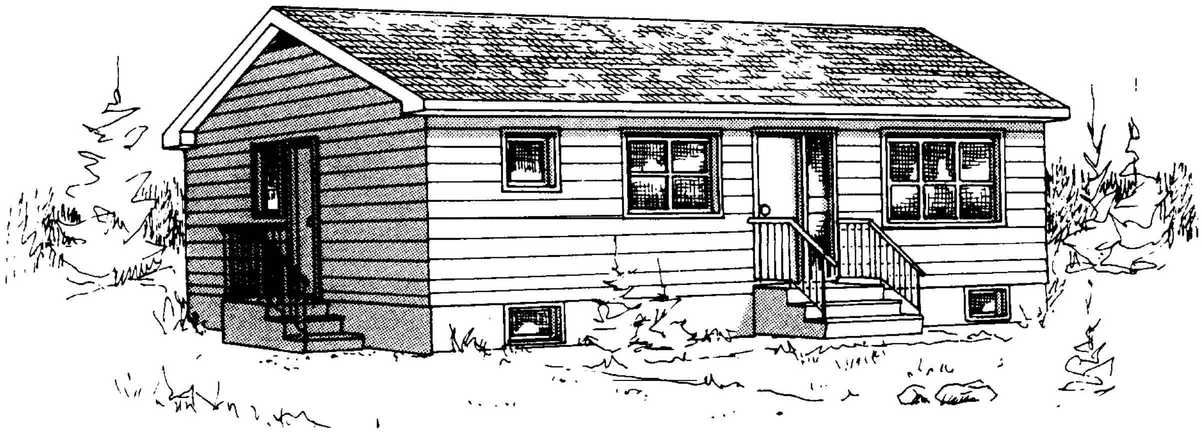
Labour -$15,596
Materials – $32,049
Freight -$14,129

For further information contact:

Mr. Norm Lawrence
Keewatin-Aski Engineers
P.O. Box 510
Sioux Lookout, Ontario, POV 2T0
(807) 737-3858

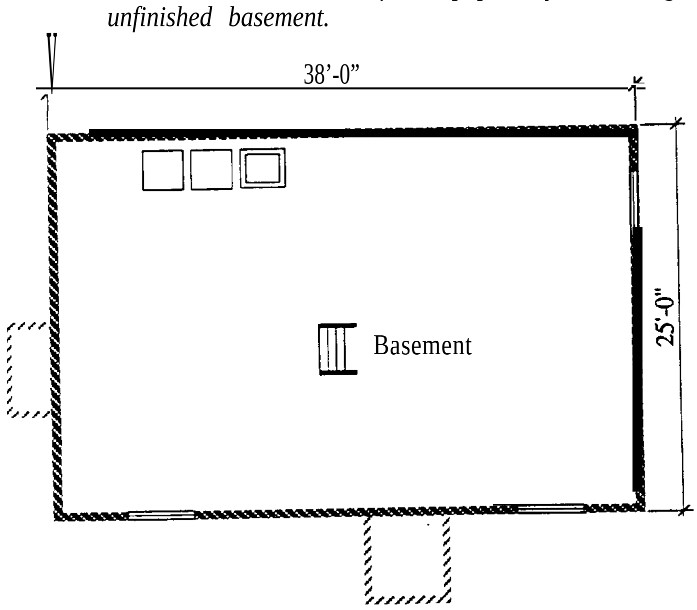
MOOSONEE – ONTARIO

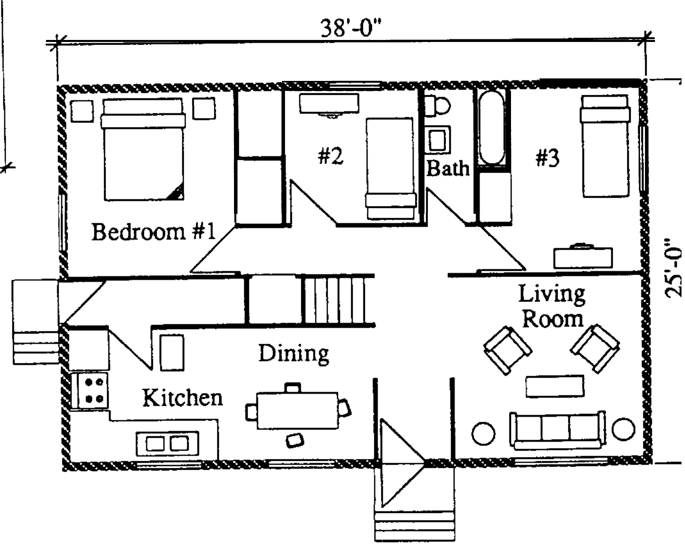




This house is a three-bedroom bungalow with a full unfinished basement. Although the design lacks some features considered essential for northern housing, e.g., an enclosed porch or vestibule, it has been built in many communities. One reason for its popularity is the large, unfinished basement.

Dimensions – 11.6x 7.6 metres (38' x24.9')
Finished floor area -88.16 m²· (948.6 sq ft)
Unfinished floor area -88.16 m²· (948.6 sq ft)





CONSTRUCTION

The house is standard frame construction, (i.e. 140 mm (6") stud walls) on a poured concrete basement. The basement specifications call for full height interior insulation.

High-heel roof trusses permit generous insulation levels over the wall top plates.

A more energy-efficient version of the design includes exterior and intenor strapping to permit additional levels of wall insulation, higher levels of basement insulation and an air to air heat exchanger.

Although these energy-efficient specifications were available, the quoted price was too high and it was decided to use the standard version for the Moosonee project.

Windows are 12 mm, triple glazed, vinyl clad sliders.

Thermal Values:
Foundation Walls - RSI 2.1 (R12)
Above-Grade Walls - RSI 3.5 (R20)
Attic - RSI 9 (R52)

OPERATION

The house is designed to be heated with a conventional oil furnace and forced air distribution. Ventilation is provided by exhaust fans in the kitchen and bathroom.

The units are sited on serviced lots with water and sewage hookups.

PERFORMANCE

Energy performance data for the particular models of this house that were prefabricated and installed in Moosonee are not available. However, this design has been widely used in northem Ontario. In Armstrong, both versions of the house have been monitored for energy consumption. The study compared actual performance of the units against estimated performance of a similar home built to conventional construction standards.

When compared to the conventional construction, the most energy-efficient model represented a saving of 45% and the standard version a saving of 32%.

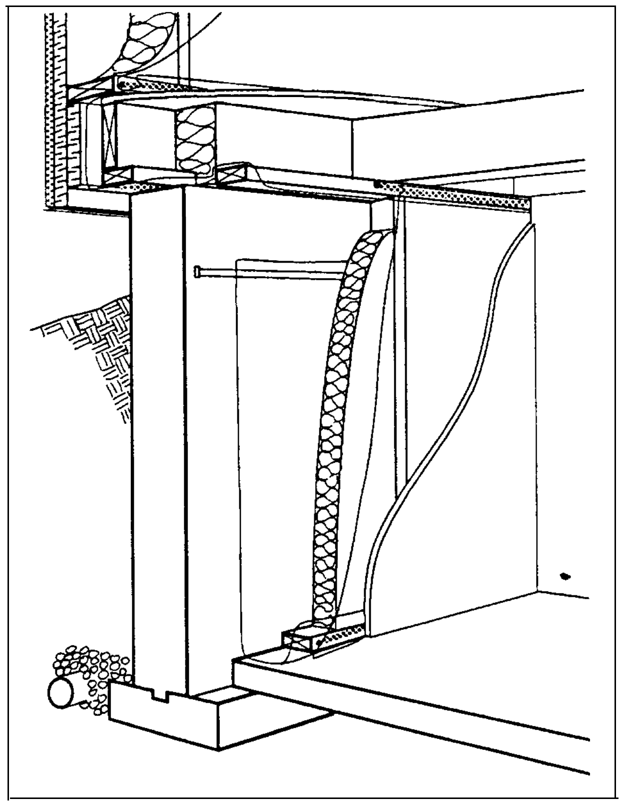
FEATURES

This standard design has been widely used in the north. Although it lacks many of the features desirable in northern housing, the design has remained popular because of two main features:

1. Builders like the fact that it is a simple, straightforward design and is easy to build.
2. Occupants like the large unfinished basement which offers workspace, storage area and extra living space, as needed.
3. Full height basement insulation means that the basement space is warm, loses little heat, and is easily finished off.

Full Height Insulation

Full basements have the advantage of adding a large storage and potential living space to a dwelling. However, unless properly insulated they can be extremely uncomfortable as well as be responsible for up to thirty per cent of home heat loss.



Basements can be insulated from the inside or the outside. The method used in the Moosonee house – interior framed wall – is one of the quickest and least expensive methods of installing insulation the full height of the basement wall.

In the past, frost heave has been a problem thought to be associated with insulating basements to their full height. However, with proper drainage techniques, e.g, burying the footings below the frost line, removing the frost susceptible soils and replacing them with a coarser material such as gravel, frost heave should not be a problem.

DESIGN AND ARCHITECTURAL NOTES

This design was originally published in 1983 and a second version was produced in 1984 to reflect rising concerns about energy use. The design has been built extensively throughout northern Ontario in both versions.

This was one of the earliest designs produced by CMHC for northern communities. The design group at CMHC has since produced a number of plans that are more appropriate for northern locations, with features such as vestibules, outdoor and indoor storage and interior finishes of wood. The agency is hoping that, although builders and clients may not be as familiar with these new designs, they will be used more often.

BUILDER NOTES

For the Moosonee Housing Development Project, ten houses were to be built under the Rural and Native Housing Program using a combination of a qualified general contractor and local skilled and unskilled labour force.

Due to a late start on the building season, the five examples of this design were not site-built but were prefabricated by Quebco Ltd. and shipped to the site from their plant in Val d'or, Québec. Quebco supplies a large number of prefab homes to northern communities, mostly from their own designs. Quebco reported that the design was easy to fabricate and presented no special problems.

A builder who has completed this model on site in other communities reported that it is very straightforward to build. The plans are easy to follow but construction would be easier and less costly if the plan would be drawn in imperial rather than metric. Since most wood is still imperial, building in metric involves a lot of waste. It is also more time consuming as the labour force in remote areas is less accustomed to metric.

Builders comment on the flexibility of this design. A different look can easily be obtained by using a cottage roof, adding shutters, enlarging the picture window or removing stub partitions on the interior. The plan can also accommodate an enclosed side porch or a split-level front entrance. This design would allow more flexibility for homeowners wishing to finish the basement if all services (sump pump, hot water tank, electrical panel, etc.) were grouped in one area of the basement.

RESIDENT REVIEW

The main criticism made of this design is that the house looks too slick and urban. Specifitally, the clients did not like the look of the aluminum or vinyl siding and painted drywall finishes. A desire for more accessible storage space and buffered entry was also expressed.

COSTS AND CONTACTS

The total cost for the prefab unit – including freight - in 1984 dollars was $79,900.

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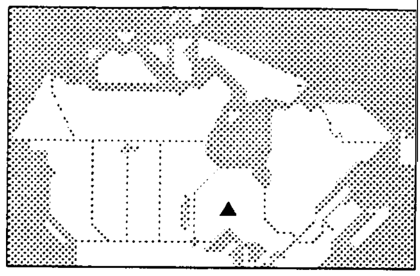
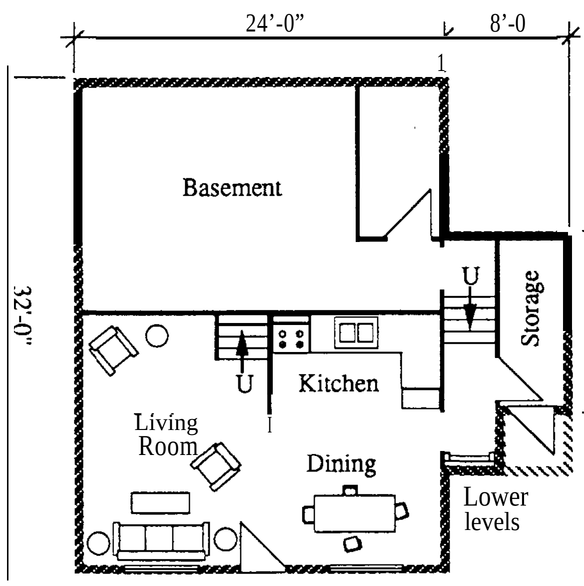
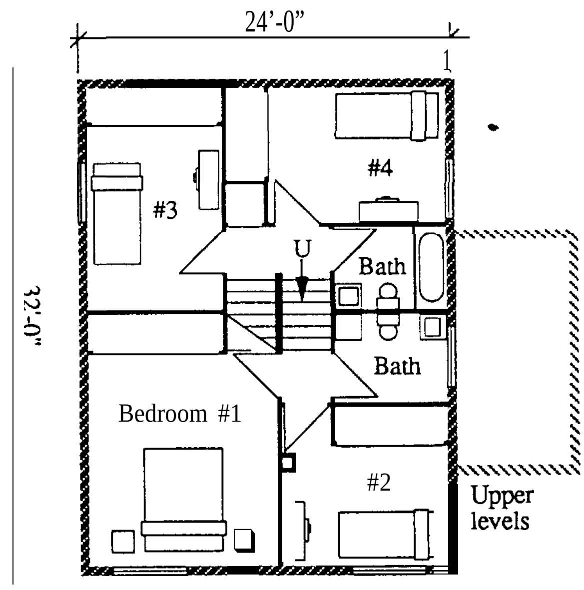
ARMSTRONG - ONTARIO



This is a four-bedroom split-level design. It is an energy- efficient house and can be heated with a propane or oil furnace or with a woodstove and oil backup. The house has passive solar features and includes a controlled ventilation system with an air to air heat exchanger.

Dimensions -7.2 m x 9.6 m (23.6' x 31.5')
Finished living area -110.36 m', (1186 sq ft)
Unfinished living area -33.12 m^2, (354 sq ft)
Unheated areas – 8.16 m', (85.8 sq ft)





CONSTRUCTION

The split-level house sits on an uninsulated concrete slab basement floor. The design uses an innovative stand-off wall system which consists of a semi-structural panel attached to 2 girts. This detail minimizes the amount of finish material required and allows the vapour barrier to be sandwiched between the two layers of insulation.

Windows are Lowen 12 mm triple glazed fixed or awning type and doors are insulated metal type.

Thermal Values:
Foundation - RSI 3.5 (R20)
Above-grade walls - RSI 5.6 (R32)
Attic - RSI 9.98 (R56)

OPERATION

Various heating systems are possible with this design. The units built in Armstrong used a propane furnace, but a woodstove with a backup oil furnace would be also be feasible.

Ventilation is provided by an air to air heat exchanger with combustion air supplied directly to the furnace room.

This unit is designed for serviced lots with municipal water and sewage hookups.

PERFORMANCE

This unit was tested extensively and monitored. The study found that the house performed very well, although air leakage was higher than expected. It was thought that this was due to the difficulty of sealing the air and vapour barrier in a split-level design. The actual performance of the house was compared with estimated performance of a similar home built to conventional standards. Results showed that the energy-efficient version represented an energy saving of 49% over the conventional model. It was estimated that the house could be heated with 1,686 litres of oil or four cords of wood per year.

FEATURES

This design has several features which are particularly well adapted to northern living.

1. It includes an unfinished basement area, and an unheated storage area, both of which have direct access to outside.

2. It also includes an entry way or vestibule.

3. The design is well suited to wood heating as there is a central location for a wood stove in the main living area next to the kitchen.

4. A unique wall system which incorporates high levels of information.

The location of the two bathrooms, however, would be a disadvantage in remote communities where there is no septic system; if honey buckets are used they would have to be carried through the living area.

The Wall System

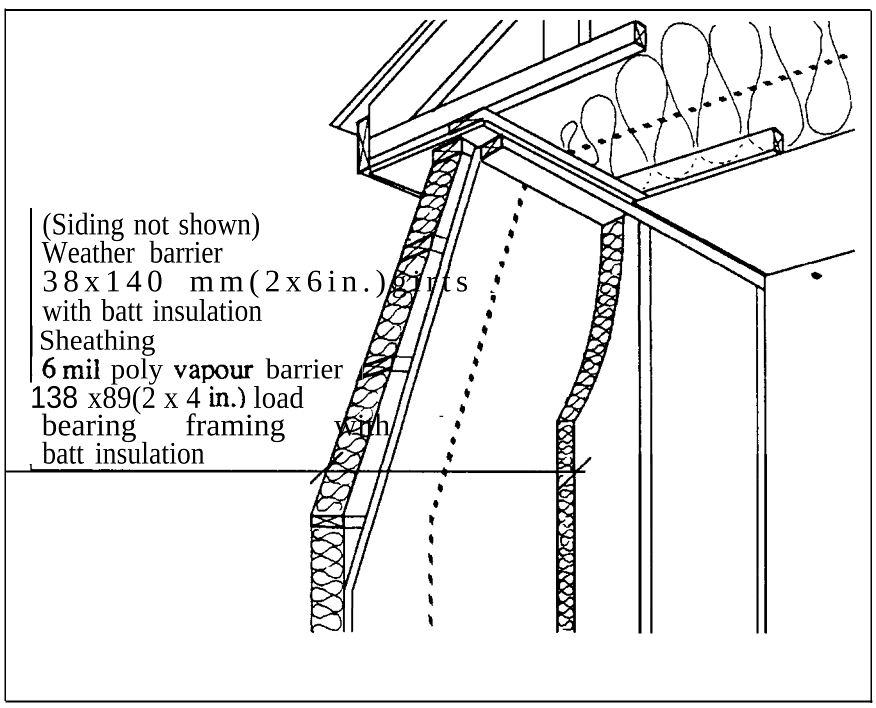
The unique wall system for this house consists of an inner structural wall of 38 x 89 (2x 4) studs set on 400 mm (1 6") centres.

Finally, the stand-off wall panel minimizes the amount of finish material required.

The outer stand-off wall consists of exterior siding, a cavity formed by 38 x 140 (2 x 6) horizontal girts and 12 mm sheathing.

The outer wall panel allows for higher levels of insulation and provides additional structural rigidity for the finished wall assembly.

This wall detail also allows for the air vapour barrier to be installed between the inner and outer wall where it is supported by the rigid sheathing and protected from damage.



DESIGN AND ARCHITECTURAL NOTES

This house was designed by Chris Jalkotsy of Solarctic Ltd. as part of a demonstration project. Mr. Jalkotsy has lived and worked in the Northwest Territories and has considerable experience in designing northern housing. During the design development stage, two meetings were held with members of the local community. As is the case with much northern housing, this particular design represents an evolutionary design process where successful elements from previous projects are incorporated and new, untried features are added.

In general terms Mr. Jalkotsy's approach to northern housing recognizes that function is the most important criteria. Because of their isolated location where services may not be available northern homes should be designed for a high degree of self-sufficiency. If local labour is to be used for construction, local materials should be used and a higher labour component emphasized in the design. Northern housing should be energy efficient and it should include outdoor storage and an indoor work area with a heavy-duty unfinished floor.

BUILDER NOTES

Four of these units were built in Armstrong in 1984 by Wildwood Estates, a building company from Thunder Bay which has built a number of houses in Armstrong.

According to the builder this design incorporates the main features of R-2000 homes, i.e. high levels of insulation, air tight construction and a heat recovery ventilator.

The stand-off wall system did not pose any special difficulties in construction. However, the builder commented that achieving the desired level of air tightness required closer site supervision. This was necessary in order to ensure that sub-trades were aware of the requirements for sealing the air vapour barrier and carried out the requirements diligently.

RESIDENT REVIEW

These were the only units of this design built by the CMHC office in Armstrong. While there were no major complaints or problems with the design, some difficulties were encountered because of client response to the heat exchangers. In some homes they were unplugged because clients felt they were too noisy while others felt that they used too much power.

Residents of one of the houses reported that it is comfortable and easily heated with the woodstove that is located in the kitchen. The only source of discomfort is the doors which are drafty. The 1/2 basement is cold and would be more useable if a heater could be installed there as well.

COSTS AND CONTACTS

Costs for this unit were not available. For plans and further information contact:
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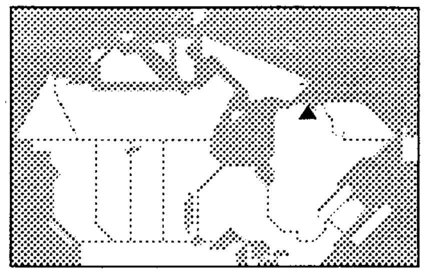
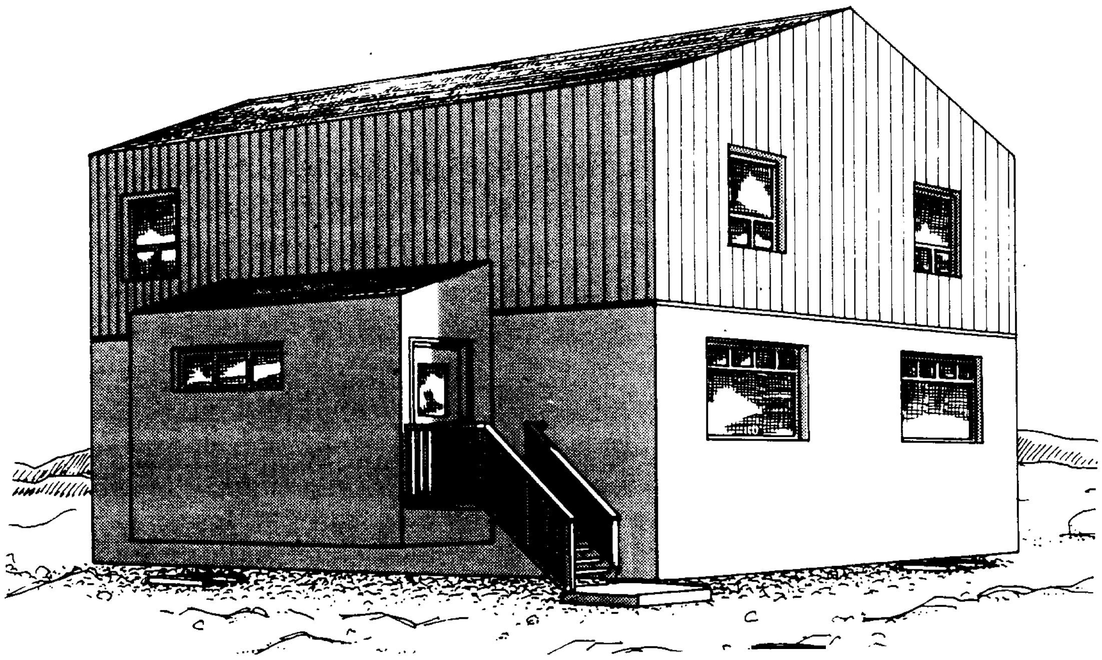
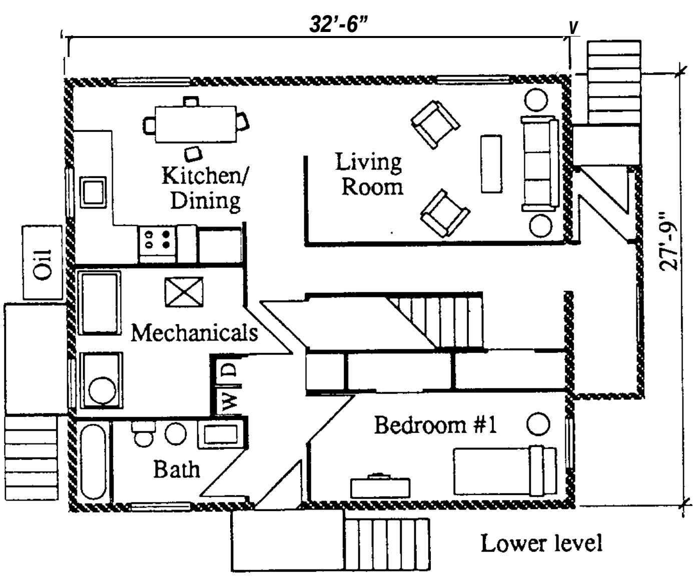
KUUJJUAQ - QUEBEC

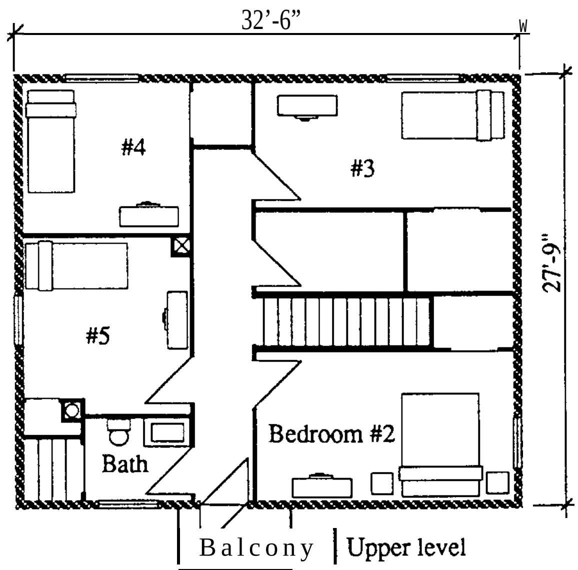




This is a five-bedroom, two-storey house designed by Québec's public housing agency (SHQ) for remote communities in northern Quebec. It is an energy-efficient design with a unique foundation system suited for permafrost conditions.

Dimensions -9.96 m x 8.53 m (32.6' x 27.9')
First floor -76.86 m² (827.3 sq ft)
Second floor -75 m² (807.3 sq ft)
Cold porch/entry - 4.97m² (53.5 sq ft)





CONSTRUCTION

Exterior wall construction is 38 x 140 mm (2x 6) studs with 38 mm (1 1/2") of rigid insulation on the interior side of the studs. 38x 64 mm (2 x 3) strapping provides a chase for plumbing and electrical between the rigid insulation and the drywall.

The polyethylene air and vapour barrier is located on top of the rigid insulation in the wall assembly. Aluminum faced gypsum board with taped joints provides the air and vapour barrier in the floor assembly.

The truss roof is insulated to high levels and includes provision for attic ventilation. Incoming air is filtered through Tyvek in order to prevent blowing snow from entering the attic.

Windows are triple glazed wood units with fixed panes below and three sliding sections above. Three opening units on each window ensure that one will be functioning should the others be frosted shut.

Thermal Values:
Suspended floor - RSI 6.5 (R37)
Exterior walls -5.7 (R32)
Ceiling/Roof -8.8 (R50)

OPERATION

Space heat is supplied by an oil fired forced air furnace and the water heater also uses an oil burner. An air intake in the mechanical room provides combustion air and fresh air for occupants.

Fresh air is circulated through the home by the furnace fan which runs continuously on low speed, switching to high speed when the furnace is on. Air is exhausted from the house through windows, the dryer vent, and the bathroom exhaust fan, which is controlled by a humidistat.

The house is designed for remote communities with trucked-in services for water and sewage. A water storage tank is provided in the mechanical room and a sewage holding tank is fitted in the insulated floor space. The bathroom is equipped with both a 'wet' toilet and a dry 'honey-bucket' unit.

PERFORMANCE

Performance information was not available.

FEATURES

This house has a number of features that make it especially suitable for northern and remote communities.

1. The suspended floor system.

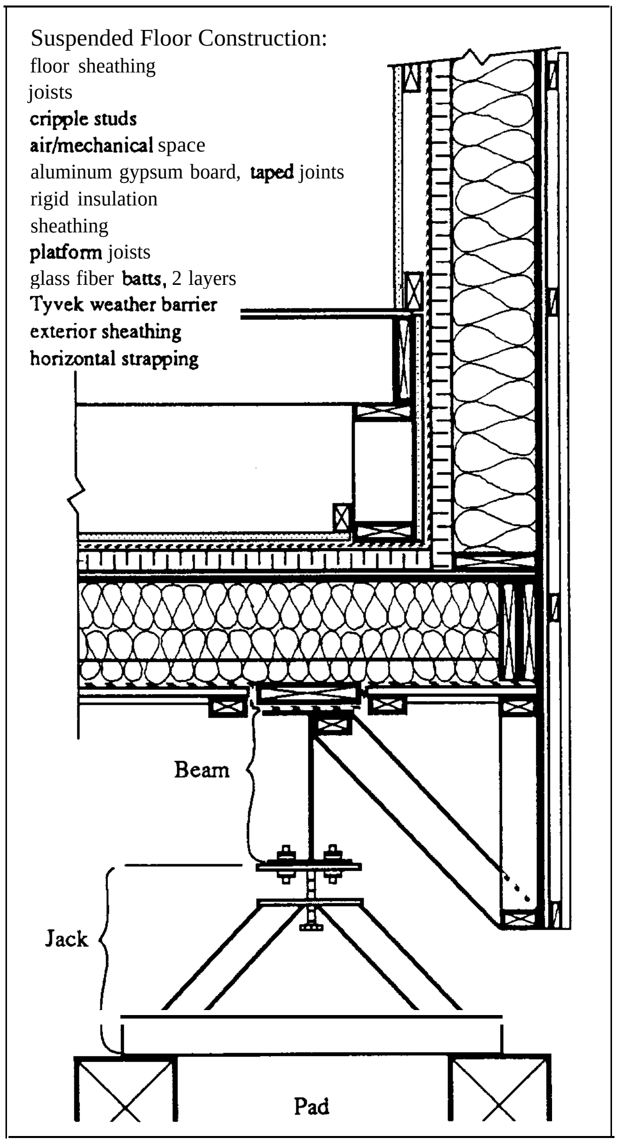
2. Storage tanks for water and sewage.

3. A separate mechanical room.

4. A heated vestibule and a cold porch.

5. A fire exit balcony from the second floor.

Suspended Floor



Of these features, the suspended floor is perhaps the most notable. Rather than reinforcing the foundation against changes in soil conditions, SHQ's strategy enables the house to 'ride' out the changes on the surface.

The key to the system is nine adjustable steel jacks which rest on pressure treated wood pads and support the steel beams that form the understructure of the house. 190 mm (8") joists resting on the steel beams provide the structure for the platform foundation of the house.

This foundation design offers several advantages. It is well insulated and has high resistance to air infiltration – resulting in a warm, comfortable floor in the house.

In addition, the raised floor assembly creates a space for mechanicals and there is sufficient space to hold the sewage tank within the insulated building shell.

DESIGN AND ARCHITECTURAL NOTES

Société d'Habitation du Québec (SHQ) has gradually evolved a set of internal design standards for northern housing. Based on these internal standards, SHQ has developed a generic design for the 14 villages that lie north of the 55th parallel. The design includes variations for detached, semi-detached and multifamily units. Working with one basic design, SHQ meets regularly with residents for feedback and adds improvements from year to year.

For 1988, the new features were the fire exit on the second floor and separate heating system controls for the first and second floors of the house.

Where SHQ has not been able to find components, such as water tanks, which will perform well under northern conditions, the agency has designed its own.

BUILDER NOTES

During the summers of 1987 and 1988,29 of these houses were built in six coastal communities. Construction is tendered by SHQ, mostly to southern contractors. SHQ also handles all material ordering and transportation and provides fully-equipped accommodation for the contractor's crew.

In order to meet the exacting demands of the climate, the construction must be precise and the plans are very detailed. SHQ provides a construction supervisor who stays on-site with the project from beginning to completion. SHQ is also supporting a program to train local tradespeople.

RESIDENT REVIEW

This design has received widespread approval in the northern communities served by SHQ. However, residents point out that there are still some areas for improvement. For example, even with the separate thermostat for the upstairs, it is still difficult to achieve even heat distribution throughout the house. There has been a problem in some houses with freezing of the sewage tank vent pipe and water supply pipes. The trap door on the fire escape balcony is difficult to open. The houses have experienced some settling since construction and not all residents have used the jacks to level them.

Residents also comment that there is not enough space in the kitchen or indoor play space for children, and there is no indoor work area. Some residents have suggested that a bungalow with a full basement would provide the indoor work and play area that is needed and be more acceptable to people who aren' t used to two storey structures.

COSTS AND CONTACTS

Costs were not available at the time of printing. For plans and further information contact:

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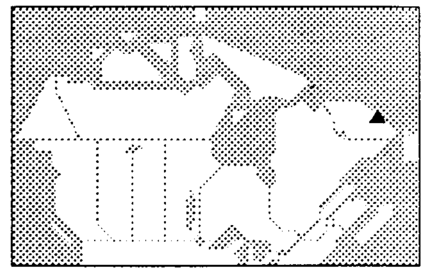
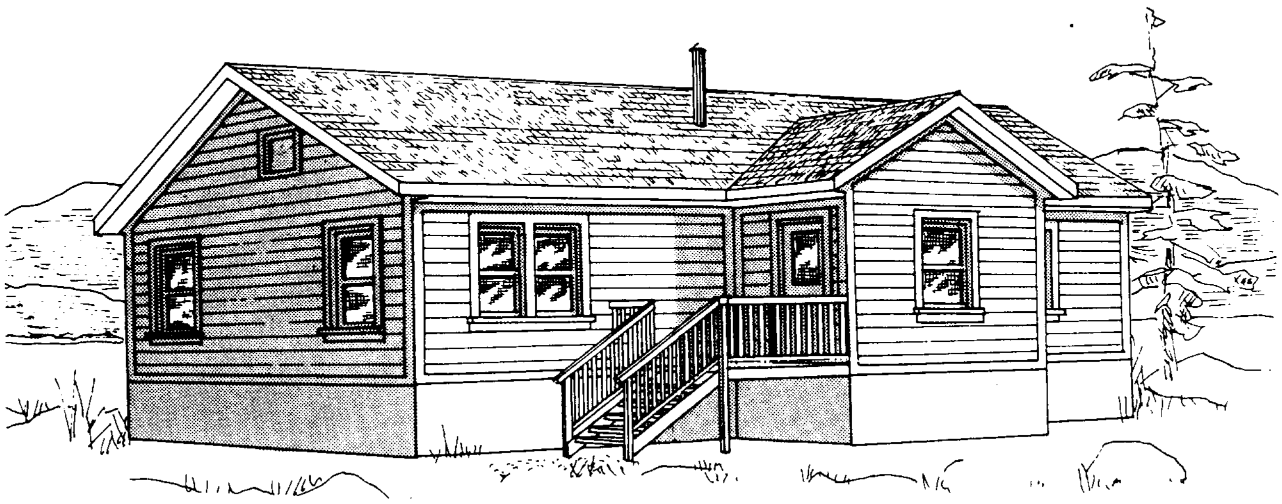
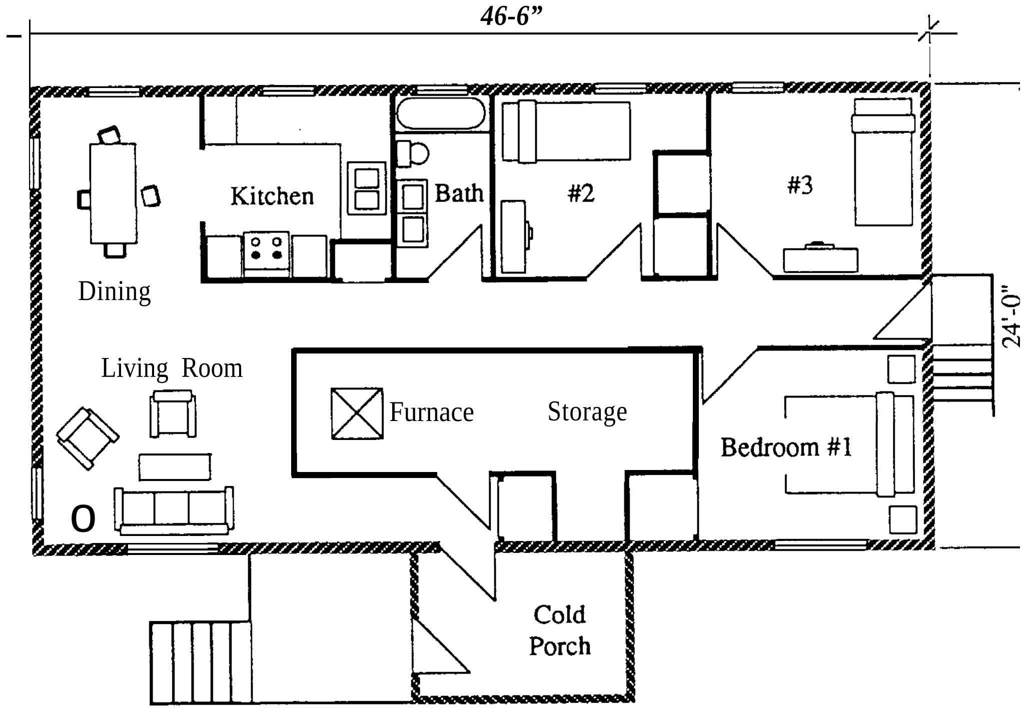
LABRADOR HOUSE





This is a three-bedroom bungalow constructed on concrete piers. The design was developed for the Newfoundland and Labrador Housing Corporation. The house includes a separate mechanical and storage room, a second exit from the main floor, and a cold porch.

Dimensions -12.7 m x 7.32 m (46.6' x 24")
Finished living area -92.96 m^2 (1000 sq ft)
Cold porch -10.20 m' (109.75 sq ft)



CONSTRUCTION

The house is designed to rest on reinforced concrete piers irnbedded in soil or pinned to rock. Where site conditions permit, a concrete basement can be built with full height interior basement insulation.

The wall section for the standard version is 38 x 140 mm (2 x 6) studs with Tyvek installed between the sheathing and vertical board and batten siding. The super-insulated version is double wall construction with a non-load bearing interior wall of 38 x 89 mm (2 x 4) construction.

In both the standard and super-insulated versions, the wall air-vapour barrier is installed directly underneath the drywall while the floor air-vapour barrier is laid over the top of the joists.

Windows are double glazed wood double hung units.

Exterior aluminum storms are provided for the super-insulated version. Exterior doors are insulated metal.

Thermal Values:
Basement walls – RSI 2.1 (R12)
Floor - RSI 6.6 or RSI 6.3 (R38 or R36)
Walls – RSI 5.62 or RSI 3.5 (R32 or R20)
Attic – RSI 8.26 or RSI 7 (R47 or R40)

OPERATION

The house is heated with a combination oil and wood forced-air furnace which is located in a separate mechanical room. The super-insulated version is also equipped with a woodstove that has a separate combustion air supply.

The standard units are ventilated by kitchen and bathroom exhaust fans while the super-insulated version is equipped with a heat recovery ventilator. The plans assume that the house will be serviced by a well and septic system or by municipal services.

PERFORMANCE

Performance figures not available.

FEATURES

There are several features which make this design suitable for northern housing.

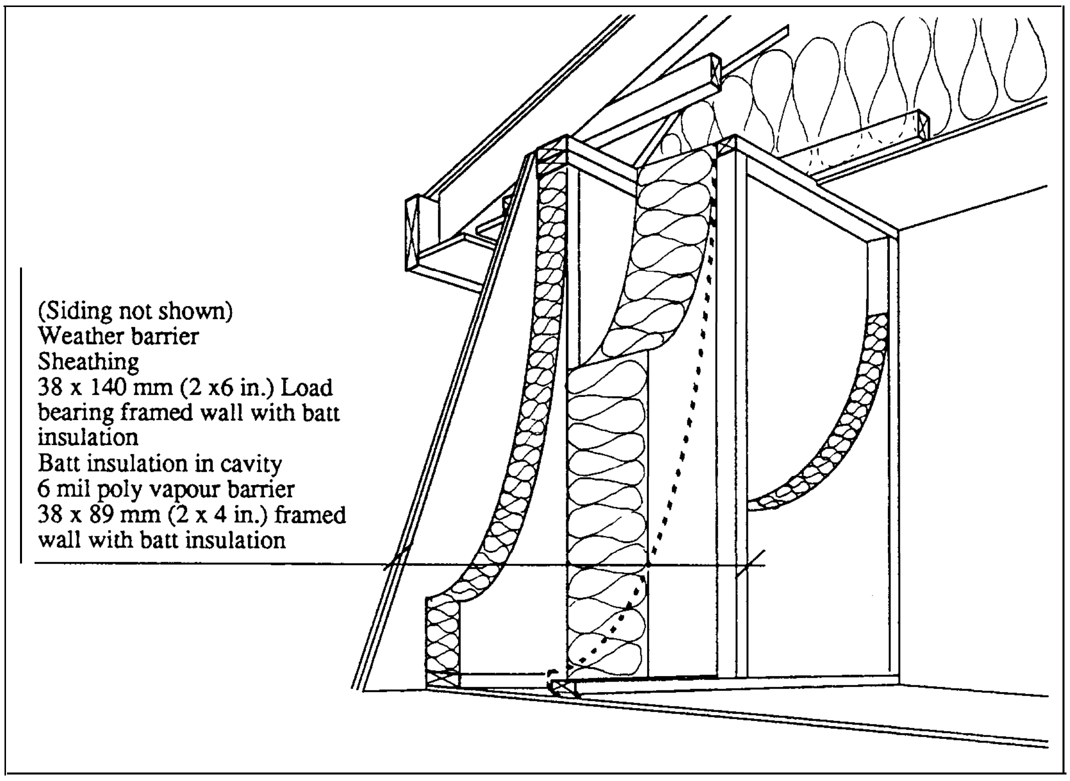
1. The concrete pier foundation.
2. The double wall and floor system.
3. The separate mechanical room with storage space and the cold porch.

Double Wall

The double wall allows for higher levels of insulation than interior strapping. The staggered studs reduce thermal bridging through the wall assembly and, if desired, the interior and exterior walls can be separated, allowing for even more insulation.

The first layer of the double floor assembly consists of 38 x 190 mm (2x8) joists resting on the built up beam and the concrete piers. This joist space is insulated with fibreglass and sheathed on both sides with plywood. The polyethylene vapour barrier is installed on top of this 'first' floor.

The second layer of 38 x 140 mm (2x6) joists with tongue and groove plywood flooring is installed directly on the fiist platform and this joist space is insulated as well.



DESIGN AND ARCHITECTURAL NOTES

In the late 1970's Phillip Pratt was commissioned by the Newfoundland government to do a study of native housing. The study suggested two prototypical designs that would be more responsive to the needs of northern residents.

Later, when the Newfoundland and Labrador Housing Corporation received funds for the design and construction of native housing, Phillip Pratt was engaged to design the houses. The initial designs presented to the community were developed from the earlier work on the housing study. They included small bedrooms and a large open living space. The roofs were steep, creating a loft space for an additional sleeping area.

The response of the community representatives however, was that these houses were too 'different'; the community wanted houses that looked more typically North American. The eventual design shown here reflects these concerns.

BUILDER NOTES

Twenty-two of these units were built in 1986 and 1987 in five Labrador communities under the supervision of the Newfoundland and Labrador Housing Association. Two super-insulated units were built in Hopedale and Nain. The Hopedale units were built by a contractor while construction of the Nain houses was handled by the Housing Corporation. Both sites used building crews and tradespeople from Labrador communities and experienced construction superintendents to advise the crews on sequencing and construction details.

The super-insulated houses took about a week longer to build than the standard units. The double wall was not difficult to build; compared to the standard house it simply involved an additional step rather than an entirely different construction method. However, the double floor system required care with sequencing.

RESIDENT REVIEW

The Tomgat Association has modified the basic design described here to accommodate the lifestyle and practical concerns of northern residents. For example, the locally designed houses have a 'great room' or open kitchen, dining and living area with a woodstove.

Problems were experienced with shifting in the earlier models built on piers. For this reason and also because concrete is not readily available, the Association has moved to a preserved wood foundation with a crawlspace.

COSTS AND CONTACTS

Cost of the standard Nain unit was $59,075; and $62,075 for the super insulated units.

For further information contact:
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WHITEHORSE RETROFIT

The house is located in Whitehorse, Yukon. The winters,. while long and cold, are quite dry, with heating degree days typically in the 12, 550 degree day range.

Project History

This project was carried out under the guidelines of the 'Saving Energy Action Loan' program of the Yukon Department of Economic Development. Under this program, an interest free loan of $3,000 was available to clients to undertake a variety of typical retrofit measures.

One of the houses retrofitted under the program is a wood frame one-storey house 9.7 m (32 ft) by 7.1 m (21 ft) built over an unheated crawlspace 2 m (6.56 ft) below grade. The house was built in 1969. Two additions, a porch and an office, had been added over unheated crawlspaces at a later date.

Description

The house before the retrofit was extremely cold and drafty with an annual heating bill of $1,741. The major areas of air leakage were around the chimney, the plumbing stack, the junctions between the existing building and the back porch and office, doors and windows, and the attic hatch. In short, there was little to keep the wind out or the heat in.

An energy audit of the building revealed the following characteristics:

- Windows throughout the building were of wood frame and double pane. Doors were of solid wood.
- The ceiling over the main structure had an estimated 100 mm (4") of fibreglass batt insulation or RSI 2.46 (R14).
- A discontinuous vapour barrier was present in some parts of the house, but there was no sign of an air barrier.
- The crawlspace under the main structure had a minimal amount of insulation in its walls; the crawlspace under the additions had no insulation.

- The floor under the main structure was not insulated; the floor under the additions was insulated with about RSI 3.52 (R20).
- The average annual energy inputs are five cords of wood and approximately 20,000 kWh of electricity.

Based on this, it was decided to carry out measures associated with a 'moderate retrofit'. This included:

- Installing an additional RSI 3.52 (R20) of fibreglass insulation in the walls and RSI 7.04 (R40) in the ceiling.

- Insulating the exterior of the crawlspace perimeter with styrofoam SM RSI 3.52 (R20), and covering the exposed dirt crawlspace floor with a 10 mil polyethylene moisture barrier. In addition, the crawlspace floor was insulated to RSI 7.04 (R40) with fibreglass batts and rigid fibreglass insulation.

- Replacing the windows with double-glazed thermopane units and replacing the existing doors with insulated steel clad units.

- Carrying out a complete air sealing program (caulking, gasketing, and weathersrnpping)

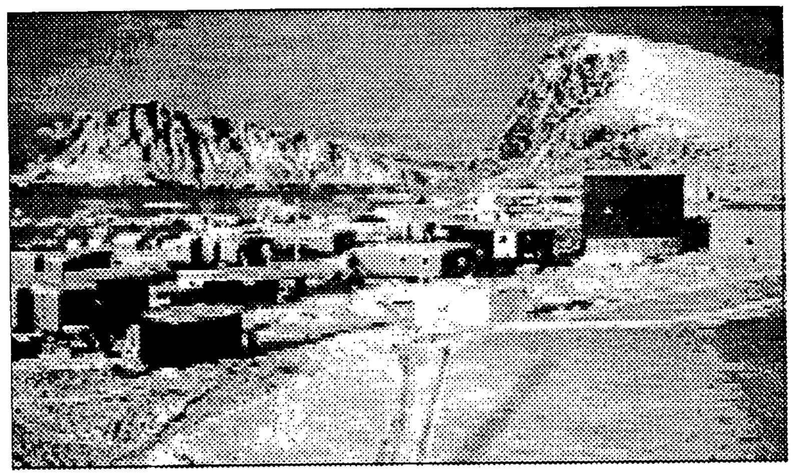
- Wrapping the hot water tank with tank and pipe insulation

Costs and Payback

The calculations provided by the audit indicate that the" annual heating costs should be in the neighborhood of $505. Based on this, a savings of $1,236 per year could be realized with a simple payback of between five and six years. However, like most retrofits, not all of the benefits can be measured in dollar costs alone. The owners have extended the life of the house, and created a warm, comfortable, more healthy place to live.

GRISE FIORD RETROFIT

Grise Fiord is a small community located on the southern tip of Ellesmere Island in the Northwest Territories. Winters are long, very cold and dry, with heating degree days typically in the 12,000 degree day range. In 1988, there were about 30 households in Gnse Fiord and a population of about 120.



Project History

The Grise Fiord Energy Awareness and Incentive Program to Reduce Energy Consumption is a combined community outreach and energy retrofit demonstration program developed by the Government of the Northwest Territories, Department of Public Works and Highways, Northwest Territories Housing Corporation and Energy, Mines and Resources Canada. Its aim has been to show how an incentive and awareness program, which involved an entire community, could be used to reduce overall energy consumption and costs.

Description

The program awarded two different prizes. A cash prize was given out to individual households that reduced their overall energy consumption by the greatest percentage over an 1 l-month period. For the community competition, a 10% reduction in fuel and electricity costs was set as a target. If the community was able to reduce consumption by this amount a variety of equipment for the community gymnasium would be donated.

Certain low-level retrofit measures were carried out as part of the program. Electric water heaters (which used expensive diesel generated electricity) were replaced with oil-fired units; and kits containing weatherstripping, caulking and plastic storm windows were given to the 18 participating households. The use of the kits was left up to the individual participants.

Results

Individual Household Competition

The six-month monitoring report for this project shows that the individual household competition has been a success. Interest and awareness have remained high. The first results show that 11 of the 18 households recorded significant savings – the highest of which was a 25% reduction in kWh consumption.

Community Competition

The 10% community target was exceeded after only five months. Overall, there has been a 36,000 kWh reduction (14%) in consumption over the May to September, 1985, period, compared with the same period in 1984.

FORT WARE RETROFIT

Fort Ware is a small community located in northern British Columbia. It was one of several communities chosen for a retrofit project beginning in 1986.

Project History

The project was carried out by the First Nations Housing Society, as well as individual bands, with funding from both the Remote Communities Demonstration Program and the Canada Mortgage and Housing Corporation. Four villages were initially chosen for the project in British Columbia: Iskut, Kyupuot, Masser, and Fort Ware. The communities and facilities ranged from those of a small modem town to very small villages of 50 houses that could only be reached by air or water.

In each community low-level, moderate, and major retrofits were carried out.

Description

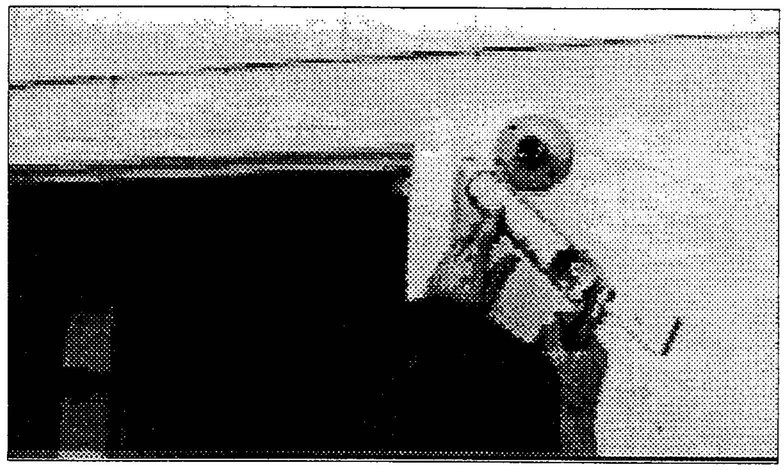
Air pressure tests carried out on houses in Fort Ware showed that the average air-change rates were two to three times higher than that found in an average urban home – 15 to 26 ach per hour compared to seven or eight. The high rates of air leakage were caused mainly by poor weather-stripping and caulking and a lack of insulation in the floor joists over crawlspace areas.

Besides the drafty nature of the houses and the cold floors, moisture problems were evident in the structure of the building itself – visible from staining on the wall interiors, and indicating potentially more serious problems in the wall cavity.

Low-level retrofit measures – a complete program of weath-erstripping and caulking – were carried out on all of the houses involved in the project. This included:

- weathersrnpping attic and crawlspace hatches,
- caulking penetrations through the ceiling, and
- sealing electrical panels.

The problem of no insulation in the floor joists was more difficult to correct because the crawlspace was often too low to allow work to be done.



Costs and Payback

It was estimated that these simple measures – involving an initial investment of a few hundred dollars – would mean savings of 10-20% on the annual fuel bill. As well, the house is a warmer and more comfortable place to live for a small investment.

ARMSTRONG RETROFIT

Armstrong is a small Ontario community located on the main CN transcontinental line, 250 km north of Thunder Bay. Winters are long and cold in this area, with heating degree days typically in the 7,000 degree day range. In 1986, there were about 130 households and a population of just over 800.

Project History

The Ontario Ministry of Energy undertook the Armstrong Remote Low Energy Housing Demonstration to document techniques which could be applied to upgrade houses in remote northern Ontario communities to improve their energy efficiency and comfort levels. Five houses underwent retrofits, with costs ranging from $2,000 to $18,000.

Description

One of the houses underwent a major retrofit. The house was less than 20 years old but was so drafty and cold that the owner was preparing to abandon the structure. It was a one-storey house with 690 sq. ft. of finished floor area and a pit basement/crawlspace. An oil-fired space heater consumed over $1,300 worth of fuel during the heating season before retrofitting.

The following improvements were undertaken:

- a new forced air oil furnace and ducting,
- refaced exterior incorporating RSI 3.52 (R20) batt insulation over a continuous air/vapour barrier,
- refaced porch entrance with the addition of RSI 2.11 (R12) batts in the porch walls and RSI 3.52 (R20) batts in the floor,

- upgraded roof insulation to RSI 7.04 (R40),
- full height basement wall insulation to RSI 1.76 (R1O),
- addition of a south-facing sunroom, adding 40 sq. ft. of floor space to the design,
- upgraded windows, doors and hot water system, and
- insulated shutters.

Like most renovation retrofits, not all of the money was used on energy-related tasks. For example, the roof turned out to be rotten and had to be replaced. One basement wall required extensive repairs to prevent it from caving in and, finally, the intenor partitions were relocated to create a more liveable floorplan.

Costs ***and Payback***

The total cost of this major retrofit came to $18,000, of which $13,650 related to energy-efficiency improvements. When viewed from a strict energy payback point of view, this project was not very cost-effective. However, recognizing that the building was about to be abandoned by the owner, it can be said that this retrofit has provided the owner with a comfortable, energy-efficient residence, at a cost far less than constructing a new house to a similar level of energy-efficiency.

KANGIRSUK RETROFIT

Kangirsuk is a small Inuit village located on the Payne - River, 13 km inland from Ungava Bay in northern Quebec. Winters are long, cold and dry, with heating degree days typically in the 8,500 degree day range. In 1985, there were about 60 households and a population of 285.

Project History

The work which was undertaken in Kangirsuk was part of a wider energy study and training program in Kangirsuk and nearby Kuujjuak, referred to as the *Kativik Energy Efficiency Program (KEEP).* Its purpose, similar to other RCDP projects, was to reduce oil dependency in remote communities not connected to the main hydro-electric grid.

To achieve this, KEEP focussed on two activities: 1) Development of an energy data base over the April to August, 1984, period, which included a technical training program for local Inuit; and, 2) Development of an energy plan for the two communities. The description which follows deals with the results of the "on-the-job" training program which saw 19 residential buildings retrofitted.

Description

The retrofitting consisted of infiltration reduction techniques grouped under the category "winterization". These included: preliminary diagnosis of air leakage paths through the use of a door fan; weathersrnpping adjustments to doors and windows, using "v" type weatherstripping; extensive caulking around windows, doors, pipes and construction seams; and the installation of plastic storm windows.

The main incentive for mobilizing action in the community was the attraction of improved comfort levels, recognizing that fuel oil and electricity bills are not paid by the tenants.

It was assumed that if the tenants understood and cared about what these winterization techniques were designed to accomplish, they would attend to their maintenance and upkeep. A detailed follow-up visit to the winterized houses in Kangirsuk confined that the quality of the materials was adequate with life expectancy depending on tenant concern.

*Costs **and Payback***

The unit cost to winterize each house was $663. The average annual heating cost, estimated, was $2,000. Air sealing techniques, it was felt, would reduce infiltration by 50%, which in turn would provide a savings of 35% on heating costs, or $700. The anticipated payback, then, would be less than one year, which is quite good – and typical.

Other benefits are no less important, however, although difficult to put a dollar figure on. They include:

- increased levels of comfort;
- reduced exfiltration of warm, moist air leading to a reduction in moisture condensation within exterior walls;
- a trained labour force;
- greater community involvement in energy conservation.

APPENDICES

- *A Glossary of Terms*
- *Foundations*
- *Metric Conversions*
- *Resource List*

A Glossary of Terms

Adfreezing The process whereby wet soils freeze to below grade materials such as foundation walls or insulation, forcing movement of the material.

Air Barrier A material carefully installed within a building envelope assembly to minimize the uncontrolled passage of air into and out of a dwelling. Air barriers may be made of either membrane materials such as polyethylene or rigid materials such as drywall. In either case, they are carefully sealed to ensure continuity.

Air Change Per Hour (ach) A unit that denotes the number of times per hour that the entire volume of air in a house is exchanged with outside air. This is generally used in two ways: 1) under natural conditions and 2) under a pressure difference of 50 pascals. A well-built house should have no more than 1.5 ach at 50 pascals.

Air Leakage The uncontrolled flow of air through a component of the building envelope, or the building envelope itself, that takes place when a pressure difference is applied across the component. Infiltration refers to air leakage into the house, and exfiltration refers to the outward leakage of air.

Air Permeability A measurement of the degree to which a building component allows air to pass through it when it is subjected to a differential pressure.

Air Pressure The pressure exerted by the air. This may refer to static (atmospheric) pressure, or dynamic components of pressure arising from air flow, or both acting together.

Air Sealing The practice of sealing (from the interior) unintentional gaps in the building envelope in order to reduce uncontrolled air leakage. All joints, holes and cracks in the air barrier should be carefully sealed with compatible caulking materials or gaskets.

Air Tightness The degree to which unintentional openings have been avoided in a building's structure.

Backdrafting (flow reversal) The reverse flow of chimney gases into a building through the barometric damper, draft hood or burner unit. Backdrafting can be caused by chimney blockage, or it can occur when the pressure differential is too high for the chimney to draw.

Building Orientation The siting of a building on a lot. The term is generally used when discussing solar orientation, which is the siting of a building with respect to access to solar radiation.

Combustion Air The air required to provide adequate oxygen for fuel burning appliances in a building.

Condensation The beads or drops of water (and frequently frost or ice in extremely cold weather) that accumulate on the inside of the exterior covering of a building (most often on windows). Condensation occurs when warm, moisture-laden air from the interior contacts a colder surface; the air cools and can no longer hold as much moisture.

Convection The transfer of heat from one point to another in a fluid (e.g., air, water), by the mixing of one portion of the fluid with another.

Controlled Ventilation Ventilation brought about by mechanical means through pressure differentials induced by the operation of a fan.

Dewpoint The temperature at which a given air/water vapour mixture is saturated with water vapour (i.e., 100% relative humidity). If air is in contact with a surface below this temperature, condensation will form on the surface.

Envelope The exterior surface of a building including all external additions, e.g., chimneys, bay windows, etc.

Fan Repressurization A process by which a large fan is used to exhaust air from a building in order to create a pressure difference across the building envelope. An analysis of the flow rate through the fan at different pressure differences provides a measurement of air-tightness.

Frost Heaving The movement of soils caused by the phenomenon known as ice lensing or ice segregation. Water is drawn from the unfrozen soil to the freezing zone, where it attaches to form layers of ice, forcing soil particles apart and causing the soil surface to heave.

Heating Degree Day The number of degrees of temperature difference on any one day between a given base temperature and the mean daytime outside temperature. The base is usually 18°C (64°F). The total number of degree days over the heating season indicates the relative severity of the winter for a specific location.

Heat Recovery The process of extracting heat (usually from a fluid such as air or water) that would otherwise be wasted. Heat recovery in housing usually refers to the extraction of heat from exhaust air.

Impermeable Not permitting water vapour or other fluid to pass through.

Intrinsic Heat Heat from human bodies, electric light' bulbs, cooking stoves, and other objects not intended specifically for space heating.

Latent Heat Heat added or removed during a change of state (for example, from water vapour to liquid water) while the temperature remains constant.

Mechanical Systems All the mechanical components of the building, i.e., plumbing, heating, ventilation, air conditioning and heat recovery.

Moisture Barrier A material, membrane or coating designed to keep moisture coming through the foundation wall from penetrating the interior foundation insulation or the wood members supporting the insulation and interior finishes.

Negative Pressure A pressure below atmospheric pressure. A negative pressure exists when the pressure inside the house envelope is less than the air pressure outside. Negative pressure will encourage infiltration.

Orientation The direction (with respect to the points of a compass) in which the building axis lies or external walls face.

Pascal A unit measurement of pressure in the S1 (metric) system. House air tightness tests are typically conducted with a pressure difference of 50 pascals between the inside and outside. 50 pascals is equal to 5.008 mm (0.2 in.) of water at 12.9°C (55°F).

Permeance Water vapour permeance is the rate at which water vapour diffuses through a sheet of any thickness of material (or assembly between parallel surfaces). It is the ratio of water vapour flow to the differences of the vapour pressures on the opposite surfaces. Permeance is measured in perms (ng/Pa.m²s, or grain/ft2hr (in. Hg)).

Positive Pressure A pressure above atmospheric pressure. A positive pressure exists when the pressure inside the house envelope is greater than the air pressure outside. A positive pressure difference will encourage exfiltration.

Pressure Difference The difference in pressure of the volume of air enclosed by the house envelope and the air surrounding the envelope.

Radiant Heat Transfer The transfer of heat energy from a location of higher temperature to a location of lower temperature by means of electromagnetic radiation.

Relative Humidity The amount of moisture in the air compared to the maximum amount of moisture that the air could retain at the same temperature. This ratio is expressed as a percentage.

Resistance Value (RSI) Thermal resistance value. This is a measurement of the ability of a material to resist heat transfer.

Sealants Flexible materials used on the inside of a building to seal gaps in the building envelope in order to prevent uncontrolled air infiltration and exfiltration.

Solar Heat Gain A term used in the passive solar heating field to describe the amount of heat gained through windows during the heating season. Net solar gain refers to the solar heat gain less the heat losses t h rough the windows.

Stack Effect Pressure differential across a building caused by differences in the density of the air due to a difference of temperature between indoors and outdoors.

Thermal Break A material of low conductivity used in a building assembly to reduce the flow of heat by conduction from one side of the assembly to the other. The term is often used to refer to materials used for this purpose in the frame of metal windows.

Vapour Diffusion The movement of water vapour between two areas caused by a difference in vapour pressure, independent of air movement. The rate of diffusion is determined by (1) the difference in vapour pressure; (2) the distance the vapour must travel; and (3) the permeability of the material to water vapour (hence the selection of materials of low permeability for use as vapour diffusion retarders in buildings).

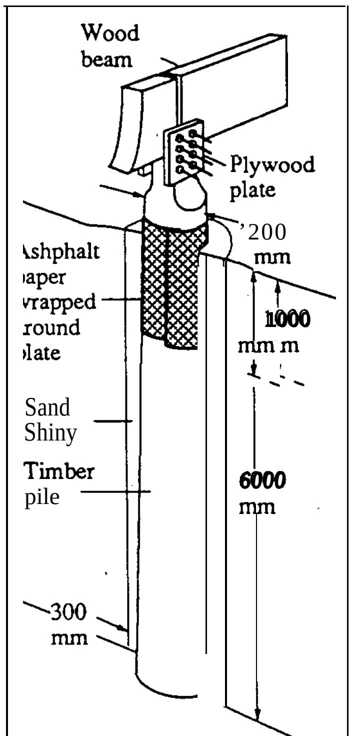
Vapour Barrier. Any material of low water vapour permeability used to restrict the movement of water vapour due to vapour diffusion. There are two classes of VDRS. A Type *I* VDR has a permeance of 14.375 metric perms (0.25 perms in imperial units) or less. A *Type II* VDR has a permeance of 43.125 (0.75) perms or less before aging and 57.5 (1.0) perms or less after aging. Any material with a perm rating higher than 57.5 (1.0) perms is *not* a VDR.

Water Vapour Pressure The pressure exerted by water vapour in the air. Water vapour moves from an area of high pressure to an area of low pressure.

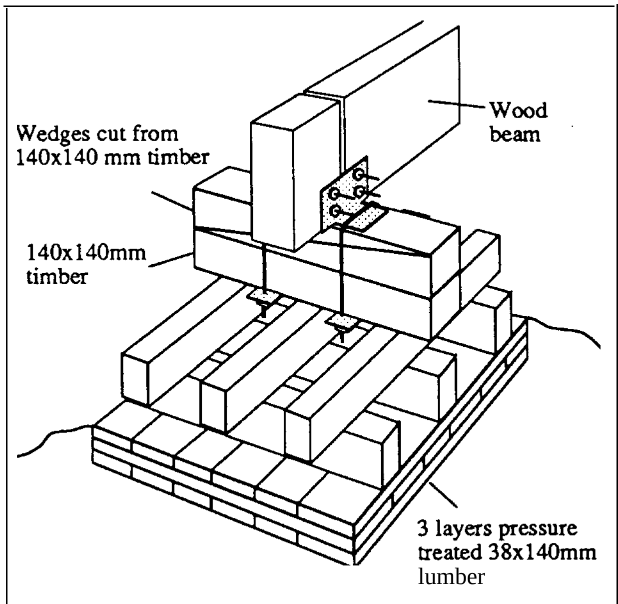
Foundations

The success of the house is often dependant on the foundation system. This is especially true in remote and northern areas where foundation systems can be subject unpredictable soil movement. The support systems detailed in the chart below, and illustrated on the following page have all been successfully used in areas subject to discontinuous and continuous permafrost.

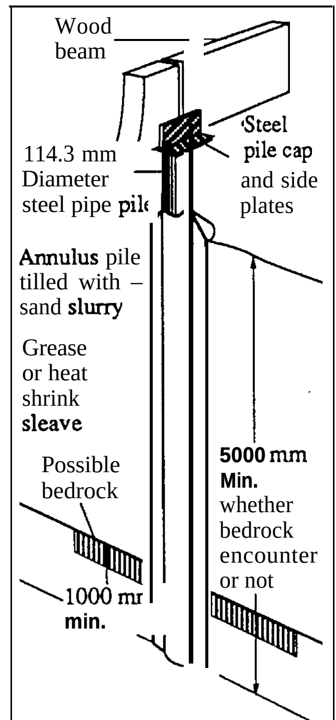
Type of support	Advantages	Disadvantages
Piles (steel or wood)	Foundation movement is generally minimal. These foundations can be placed at any time of the year, however the best time is in the early spring. They generally can be installed for under $20,000.	Large pile movements have occured in isolated instances, causing significant damage to houses. Drilling equipment may not be available in most remote communities.
Surface or shallow spread footings	These foundations are easy to construct, and can be placed at any time of the year. They require little in the way of skilled labour. They generally cost between $17,000 and $18,000.	Significant footing movement can occur. Because of the number of footings these foundations are difficult to level. They require a well compacted pad. Erosion of the pad can sometimes undermine the footing.
Deep spread footings	Foundation movement with this type of foundation are generally very small. They require little in the way of skilled labour to construct. They can cost as much as $25,000 to install.	These foundations require a lot of time and care to construct, including a significant amount of site work. Placement is generally limited to the summer months.
Three-point metal space frame	Foundation movements will not damage the house. House loads are transferred through many points to the ground. They can be placed at any time of the year, and do not require skilled labour. They can be constructed for under $20,000.	Levelling, if required, can be difficult. A level pad is required.
Multi-point metal space frame	Foundation movement will not damage the house. They are easy to level, and can be placed at anytime of the year. They can be constructed for under $20,000.	Large support loadings may overstress the ground. A well compacted gravel pad is required. Specialized engineering design and construction may also me required. Limited to buildings of roughly square dimensions.



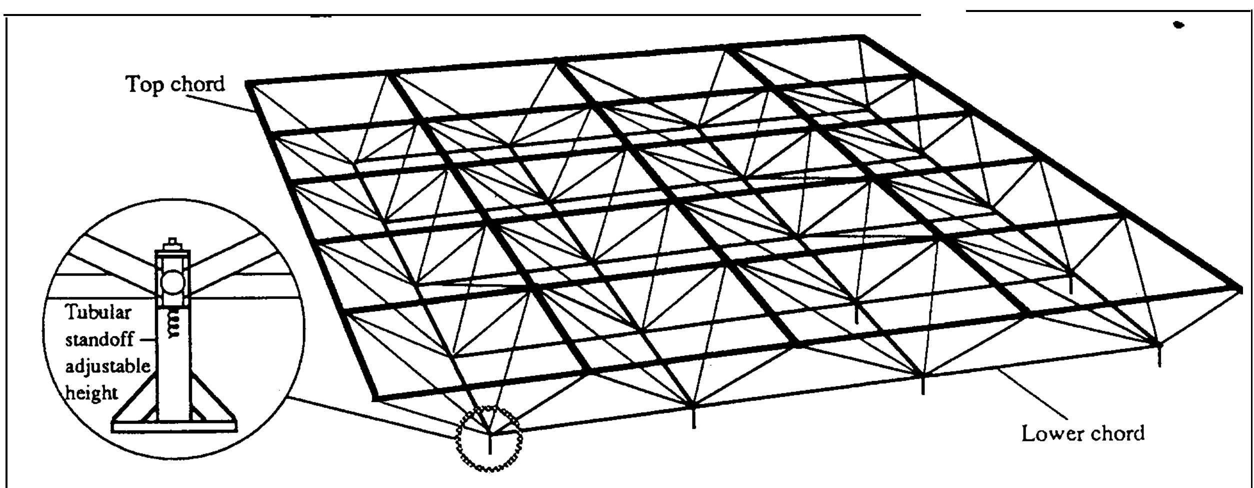
Wood Pile



Surface Wood Pad



Steel Pile



Space Frame and Support Detail

Metric Conversion

Imperial	**Metric**
2X2	**38x38** mm
2x3	38x64 mm
2x4	38x89 mm
2x6	38x140 mm
2x8	38x190 mm
2X1O	38x235 mm
2X12	38x286 mm
2'x8'	600 X 2400 mm
4'x8'	1200 X 2400 mm
16" OC	400 mm
24" OC	600 mm
1"	25.4 mm
1 1/2"	38 mm
2"	51 mm

Metric	**to get**	multiply	**by**
length	**mm**	inches	25.4
	m	feet	0.3048
area	m^2	ft^2	0.0929
		yd^2	0.836127
volume	m'	ft^3	0.028317
		yd^3	0.764555
flow	l/s	cfm	0.471947
energy	W	Btu/hr.	0.293072
insulation R value	RSI	R	0.1761
insulation R/unit thickness	RSI/mm	R/in.	**0.00693**
mass	kg	lb.	**0.454**
permeance (water vapour)	$ng/Pa.m^2s$	1 $grain/hrft^2$	57.5
resistance to moisture fl	$Pa.m^2s/ng$	1 $hft^2h/grain$	0.0174

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