THE DESIGN AND EVALUATION OF SUSTAINABLE HOUSING FOR THE CANADIAN FAR NORTH

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ABSTRACT

The Canadian Arctic is a region of extreme cold, where, as the result of the high cost of shipping goods and fuel, building and operating housing can cost times more than in southern Canada. In addition, the arctic is home to a unique aboriginal culture that has survived for millennium in one of the harshest regions of the world. To address escalating heating costs and to bring greater cultural sensitivity into the design process, CMHC is working in partnership with First Nations and Inuit communities, and northern housing agencies to design, construct and monitor the energy performance and cultural acceptance of new northern housing prototypes.

This paper will examine the design and development process undertaken for this project. It will describe the use of design charrettes, the design process used to produce house designs that complement the life styles of Inuit and First Nations families, the designs that evolved from this process, and occupants’ insights and level of acceptance of the design. The paper will highlight the importance community involvement in the design process.

The paper will examine the challenges of constructing projects in remote northern communities. It will examine the design of the building envelope and the energy modeling carried out as part of the design process. The paper will include the initial results of the energy monitoring and the anticipated energy savings of the houses, illustrate important issues for designers working on housing in cold climates, demonstrate the use of new products and innovative construction methodology, and
provide important insights for designers and builders interested in better performing and functioning buildings.

The paper will illustrate the success of this joint project between CMHC and northern housing providers, and demonstrate the potential for improving the environmental and cultural sustainability of housing in the far north.

Key words: Design, housing, sustainable, Canada

Introduction

With rising energy costs it has become increasingly clear to northern governments, housing agencies, homeowners and occupants that present energy use and utility service costs are increasingly not affordable or sustainable. On a variety of fronts there is a need for innovative solutions to help address this growing concern. Throughout Canada present energy use practices are having a negative impact on the environment through climate change and its growing impact on northern environment. In addition, it has been recognized that many housing models in the north have not adequately reflected the culture and lifestyle of northern communities.

To assist in addressing this issue, CMHC partnered with northern housing providers to carry out the integrated design and evaluation of a constructed Northern Sustainable House (NSH) prototype. The goal of the project was to design a culturally appropriate energy efficient northern house that consumes 50% less energy than the Model National Energy Code for Houses (MNECH).

For this project, two models for the NSH were developed – a model for Inuit communities in the eastern artic developed in partnership with the Nunavut Housing Corporation (NHC) in Arviat, Nunavut, and a model in the western arctic developed in partnership with the Trond’ek Hwe’chen First Nations Community in Dawson City, Yukon.

To address cultural issues the project included carrying out house design charrettes in the two communities. The design work was carried out directly with the northern housing providers to construct and evaluate the performance and design initiatives for the NSH Prototype. For each house, design teams and review teams were established, alternative construction/insulation systems were developed, and energy modeling to evaluate the design performance of the designs was carried out.

This paper will examine the development of the design for the CMHC – NHC Northern Sustainable House.
The CMHC/NHC E2 House

The design of the NHS prototype for Nunavut was carried out in partnership by CMHC and the NHC in the community of Arviat, located on the north western shore of Hudson’s Bay in Nunavut. Technically, the project was designed to build upon the work carried out by the NHC and CMHC, on the NHC 5-Plex, a complex designed to perform 25% better than the MNECH.

Arviat House Design Charrette and Workshops

To initiate the design process, a one day house design charrette with participants from the community, a half day technical workshop with the technical staff of the NHC, and a half day design charrette with Inuit women from the community were held in Arviat. These events were organized to provide a forum for gathering ideas on cultural needs, technical challenges and the requirements for housing in Nunavut.

Defining Inuit Needs

The charrette began with comments from Inuit elders in the community. Traditionally the Inuit were a nomadic people. As the Inuit were moved into permanent settlements they began to suffer from a number of things. For example, overcrowding has become a major issue, often occurring as a result of other family members (a family with children) needing to move into the house of their parents, with the resulting stresses of large extended families living together.

Joe Karatek, an Inuit facilitator from Arviat, went on to add further perspectives on the issue of house. Joe noted that the family/neighbor hierarchical structure in a hunter gatherer society (as the Inuit traditionally are) is fundamentally different from that of the society of a permanent village or town. Where towns were developed by a set of laws and expectations, these were not ideas/rules that the Inuit were used to. When moved to towns, the Inuit lost their laws without gaining an understanding of the other laws that were imposed upon them. There was no planning for the social structure of the Inuit, to the extent that there is still is no social council, an important concept in traditional Inuit social structure. Many problems in the family and between neighbors have been created and escalated by bringing many more people together than the Inuit are accustomed to.

During this discussion, it was identified that one of the key elements of the Inuit house is that it has traditionally been a place of two seasons, with two very different lifestyles that occurred in two or many more locations. The Inuit, who traditionally were nomadic and did not have a house as we know it, had very different structures for different seasons (e.g. snow houses in winter and skin houses in summer). This recognition, and the challenge that came with it, became integral to the project and...
assisted a number of other discussions in focusing on what this means to the Inuit house today. Essential along with this, was the recognition that the need to the importance of family and neighbors – an integral part of the Inuit way of life – with the added complexity that the Inuit family is changing.

**Exploring Problems and Generating Ideas**

**The Elders**

An important point highlighted was that people need (and have not had) a better sense of where life is taking them. The question was raised, ‘How do we address these issues?’ had not been asked of people before – making this in some ways, new territory to explore. In approaching this question a number of aspects of the house that need to be addressed were raised. These included:

- Houses need to be able to adapt to the changing needs of a large extended family - providing a connection to shared common space, while providing for individual space.
- Designing the house to have a summer and winter entrance - considering the prevailing winds – with the west being the preferred location in the winter to keep the entrance clear of snow, and the south being the preferred entrance in the summer.
- The great need for different storage and working areas (cold, cool and warm).
- The need for a place to make small crafts (i.e. access to tools, a vice, etc)
- The need for a place to skin animals (for those who trap animals for a living)
- The need for storage areas for outdoor clothing (skins) etc.
- The problems caused when bedrooms are in different locations in the house - they are difficult to keep at the same temperatures.
- That young and old people have different needs and desires
- The need to make houses closer to the ground

**Inuit Women**

The half day charrette with Inuit women offered an additional perspective on needs in the house. Much of the emphasis in this discussion was on the need for spaces for sewing and working on skins, the need for more storage and aspects of the kitchen and sharing meals. The description of the process of working on skins provided important insights into needs of Inuit women.

When the skins are moved inside, the meat is already removed. Similar to outside, inside a house skinning and carving would be carried out on the floor. For skins that can be worked on inside (some cannot as they smell a great deal and the fur will come off in the heat), the location of the laundry tub near to where the skins would be sewn
is important for keeping any mess to a small area. Houses are generally too warm and the humidity is too low for working on skins, while frozen skins are too difficult to sew. The optimum temperature is about 2 to 5 degrees C.

A good deal of discussion revolved around the kitchen. For example, two kinds of foods are eaten in the house – country foods (raw) and other foods (cooked). It was noted by all the women that country foods are eaten on the floor while cooked foods are eaten at the table. This is in part because country foods are set out in piles of raw meat with each person able to carve and cut up pieces of meat at eat. This is often includes a larger family group where space is needed to be able to accommodate this.

Other issues identified by Inuit Women included:
- The need for more storage - Cold storage is required as skin clothing is stored outside to keep it from drying out.
- Spaces for young people. They like to have their own rooms but also need to be able to interact as a family.
- Bathrooms are too small, with no room to move and no storage.
- Larger windows to provide more daylight for sewing and to help heat the house
- Forced Air and Mechanical room: There is a problem with noise from the mechanical room and a concern with fire safety.

The Technical Group

In addition to the technical issues already raised other technical issues were highlighted in the technical session. It was noted by the NHC that it takes $24,000 per year to keep the housing units open and operating and the larger part of this was for the cost of truck delivery of water to and removing waste from houses. While it appears essential to reduce water consumption rates and costs, it was noted that water consumption rates in NHC houses are already well below the national average. Discussion of the potential for a grey water system was included. It was suggested that the design process look at total operating costs including:
- Water saving devices
- Grey water recovery (toilets represent 40% of water usage)
- Appliances
- lighting
- Mechanical system

Additional discussions focused on the issue of foundations and the variety of options that have been used in the north including screw jacks, piles, blocks and wedges, slab on grade, and space frames. While the triodetic space frame is being used for all of the 5 plex’s in Nunavut, the problems relating to expense etc. suggested that a
different option be used for the house. The development of a simple solution that could be commonly used throughout the north was seen as a necessary development.

The issue of the cost of construction was also raised. While generating savings in operating costs there was concern with the additional amount it would cost to build this house compared with present construction practices? Looking for alternative building systems (e.g. SIP’s) that would make this possible was seen by the NHC as a goal for the project. Other areas identified where there is a need for improvements included: kitchen counters and sinks, door knobs, cabinets, more light switches, more shelves, better quality steel doors, improved ventilation, and the need for a 2nd bathroom (powder room).

Overview

It was recognized that there is no one answer to many of the issues raised, that understanding the links between them is essential for dealing with the issues effectively. For the elders, the greatest importance of the sessions came with the focus on looking at Inuit culture, something that has seldom been done in the past. As these ideas drove a great deal of the design, the following provides an overview of the needs identified in this process. A modern Inuit house needs to:

- Work for different ages and needs
- Be expandable to provide for the growth of the family
- Allow for the use of new technologies (e.g. solar, wind)
- Allow for large groups to get together and eat country foods
- Be a place that includes the lifestyles of two seasons
- Be a place that meets the needs of family and encourages community
- Be a place that brings together all four of family, community, building (the cost of construction), and Operating (the cost of living)

The Design of the CMHC/NHC E2 House

The design for the CMHC/NHC Northern Sustainable House was carried out jointly by a CMHC/NHC design team. As part of the design process a design review with the original participants of the September 2006 house design charrette and workshops was held in the community of Arviat. The reception from the participants was very positive with a few design changes resulting from the review. In moving forward it was felt that issues of ventilation had to be addressed very well – that the design of the system needed to ensure that the number of people in the house be taken in to account.

Participants acknowledged that the house very effectively addressed the needs of the Inuit family, in a modest footprint. It was noted by the elders that northern living is
always based on understanding the wind and the sun, and this design did this very well. There was also a great deal of appreciation that the design process had involved them, as this had not happened before. Donald Uluadluak shared with that this had left him with the feeling of being in a newly built igloo and ‘the smell of new snow and sense of accomplishment that that comes with building it’.

Cultural Design Features

The cultural features in the house designed to address the needs of the Inuit family include (Figures 1 to 3):

- A large open concept Living Room/Dining Room/Kitchen that allow space for eating country foods
- Two entrances (Summer and winter) oriented to address local weather conditions
- A ‘Cool Room’ for sewing skins with a large laundry tub for soaking skins
- A Cold Storage area for storing skin clothing
- An isolated mechanical room
- Potential to turn the Sewing Room into an extra bedroom where needed
- Additional bedroom can be easily added of the Master Bedroom on the north east
- A ‘Sea Lift Room’ for the storage of bulk food and household purchases brought on the annual sea shipment to remote arctic communities.

Construction Details

With the goal of the project to design a northern housing prototype that consumes 50% less energy than the Model National Energy Code for Houses (MNECH), ongoing work was carried out by the design team to access and explore alternative wall and ceiling systems, and other innovations that would needed to meet the energy conservation targets for the project.

Based on input gathered within the NHC and CMHC, current building practices and ideas raised in the design charrette, two alternative wall systems were developed as options for the project (Figure 4). Wall System ‘A’ utilizes a SIP’s panel with additional strapping, vapor barrier for air tightness and insulation added to the inside of the system. This was chosen at the request of the NHC in Arviat to explore the option of a wall system that could speed up the process of construction in isolated communities. Wall System ‘B’ utilizes a double framed wall, a building technique which could be constructed based on existing skills. In both cases the floor insulation is maintained at R40, with ceiling insulation increased from R 40 to R 67. The existing wall insulation level of approx R 28 is increased to approximately R 50 in Wall System A and R 48 in Wall System B.
Figure 1  Floor Plan

Figure 2  South Elevation

Figure 3  North Elevation
Other energy features of the design include:

- Highly energy efficient florescent lighting fixtures throughout the unit
- The clustering of the bathroom/laundry/kitchen areas to reduce plumbing runs
- The use of high energy efficient oil boiler for heat and hot water
- Low water consumption stacking washer/dryer
- Isolated foyer’s at each of the entrances

![Figure 4 Proposed Alternative Wall Systems](image)

**Figure 4** Proposed Alternative Wall Systems

- The use of a shed roof to provide a south elevation for the installation of photovoltaic or solar water heating (Figure 2)
- Triple Gazed, argon filled, Fiberglass windows largely located on the south elevation
- An efficient footprint that reduces the floor area of the house
- Advanced framing details to reduce materials and thermal bridging

**Energy Modeling**

To evaluate the design energy performance of the house Energy modeling of all the existing and proposed wall systems was carried out and evaluated against the Model National Energy Code for Houses (MNECH).
The results of the modeling, shown in Figure 5, confirmed that the both Wall Types A and B would attain the targeted energy performance levels. Column 9 shows Wall A attaining a reduction of 63% (consuming 37% of the energy), with Wall System B attaining a reduction of 62% (consuming 38% of the energy). Anticipated energy costs would be reduced by approximately $4,500 per year over present practices and approximately $7,800 over the MNECH.

Conclusion

The Northern Sustainable House is an example of the innovative thinking about energy-efficient design that is taking place in Canada’s arctic and subarctic regions. As a result of the charrettes in Arviat and Dawson City, affordable, culture-sensitive, energy-efficient housing is either under construction or planned in these communities. In the charrettes, residents, housing corporation staff, and technical design professionals became aware of some of the many challenges that lie ahead. Comments collected in interviews a year later show that while participants are proud of their achievements, they realize that the Northern Sustainable House is a single step forward on a road that lies far into the future.