

Design and Construction of the Northern Sustainable House – Arviat, Nunavut

INTRODUCTION

To support sustainable housing design in the North, Canada Mortgage and Housing Corporation (CMHC) has worked with northern housing providers to conceptualize, design, build and monitor innovative highly energy-efficient housing projects in each of the three territories. The goals of the Northern Sustainable House (NSH) initiative are to demonstrate approaches to affordable, energy-efficient and sustainable housing while addressing the local housing needs and taking into account the interests of future occupants as well as the community and other stakeholders. Each of the demonstration projects followed a similar process whereby input from the local community was sought through an integrated design charrette to ensure input and buy-in from stakeholders. Participants worked to create housing designs that targeted a minimum 50% reduction in the energy consumption relative to the 1997 Model National Energy Code for Houses (MNECH) while striving to address unique cultural needs of the local community in terms of living space functionality.

This highlight provides a summary of the design and construction of the Northern Sustainable House (NSH) in Arviat, Nunavut (figure 1). The NSH in Arviat was designed and built by the Nunavut Housing Corporation (NHC).

Design charrette

Housing in Arviat is confronted with significant construction challenges such as cold weather, limited building season, shortage of skilled labour, the need for long lead times and high cost of materials and shipping. Wind load,



Figure 1 Northern Sustainable House in Arviat
(Credit: NHC)

snow drift, permafrost, and infrastructure requirements (for example truck-hauled water) add to the challenge of designing and building durable, energy-efficient and affordable housing.

The Arviat NSH began with two design charrettes and workshops in 2005 and 2006 to engage the local community and stakeholders in discussions pertaining to identified challenges as well as cultural and family demographic concerns. The objective of the charrettes was to help ensure that proposed design of the Arviat NSH would address all technical and cultural requirements.

Research Highlight

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The Arviat NSH project was specifically developed to meet the following objectives:

1. To meet the cultural and lifestyle needs of the local community with regard to housing design and performance.
2. To develop practical knowledge on energy-efficient, culturally appropriate houses in the North.
3. To compare different building envelope systems for ease of construction, maintenance and energy consumption.

The design team developed and evaluated two alternative energy-efficient wall systems for the house: a double-wall system and a 165-mm (6.5-in.) structural insulated panel

(SIP) wall assembly. The final design included features such as different winter and summer entryways, a cool room for sewing skins, and an open-concept living room/kitchen to accommodate large family gatherings. Window orientation on the south facade maximizes solar gains while the building form provides deflection from the cold northern wind. The proposed house design was presented to the original charrette participants who generally acknowledged that the design addressed the needs of the Inuit family.

Design features

The Arviat NSH is a one-storey, three-bedroom, 142-m² (1,530-sq.-ft.) open concept house that was completed in early 2013 (figure 2).

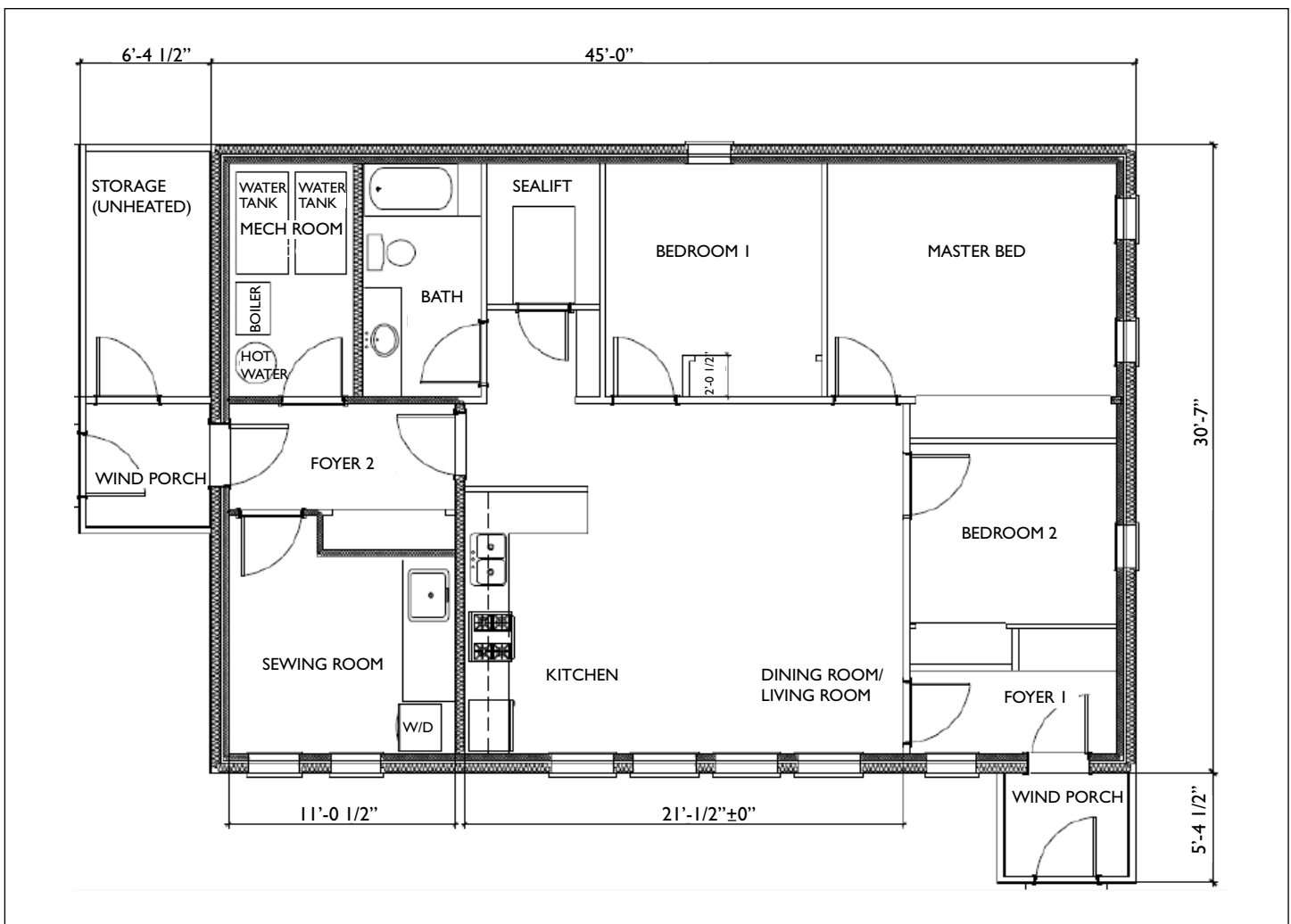


Figure 2 Floor plan of the Northern Sustainable House in Arviat (Credit: NHC)

The unit has a highly insulated building envelope, an energy-efficient oil-fired boiler, a dual-speed heat recovery ventilator, triple-glazed windows, double doors on both entryways to provide an air lock, and a shed-style roof to provide wall area for future installation of photovoltaic or solar thermal hot water system (figure 3).

Concurrent with the construction of the Arviat NSH, the NHC also built a second house, known as the E/2 SIP house, next to the NSH with the same orientation and on the same street in Arviat, to compare the performance of the houses with different wall assemblies. With everything else being identical to the Arviat NSH, the E/2 SIP house was constructed with 165-mm (6.5-in.) structural insulated panels assembly, as compared to the NSH which is stick-built using a double-wall system comprised of a staggered 38x89 mm (2x6 in.) and 38x140 mm (2x4 in.) wall assembly. The aim was to gain experience with both wall constructions, and to compare the ease of construction and energy performance of the houses given their respective wall assemblies.

Foundation

The Arviat NSH was built on a gravel pad and is supported by screw jacks that can be levelled individually as needed. An engineered laminated beam floor system supports the house. The crawl space between the gravel pad and the bottom of the floor is open to the exterior environment and is unheated. The gravel pad was laid and had time to settle for three years before the house was built.

Roof

The shed-style roof of 2:12 slope was constructed to increase the area on the southeast facade of the house for future solar panel integration. Tyvek spun-bonded olefin wrap was provided on the exterior of the roof assembly as the air barrier, and the 0.15-mm (6-mil) polyethylene near the interior of the assembly functions as a vapour barrier.

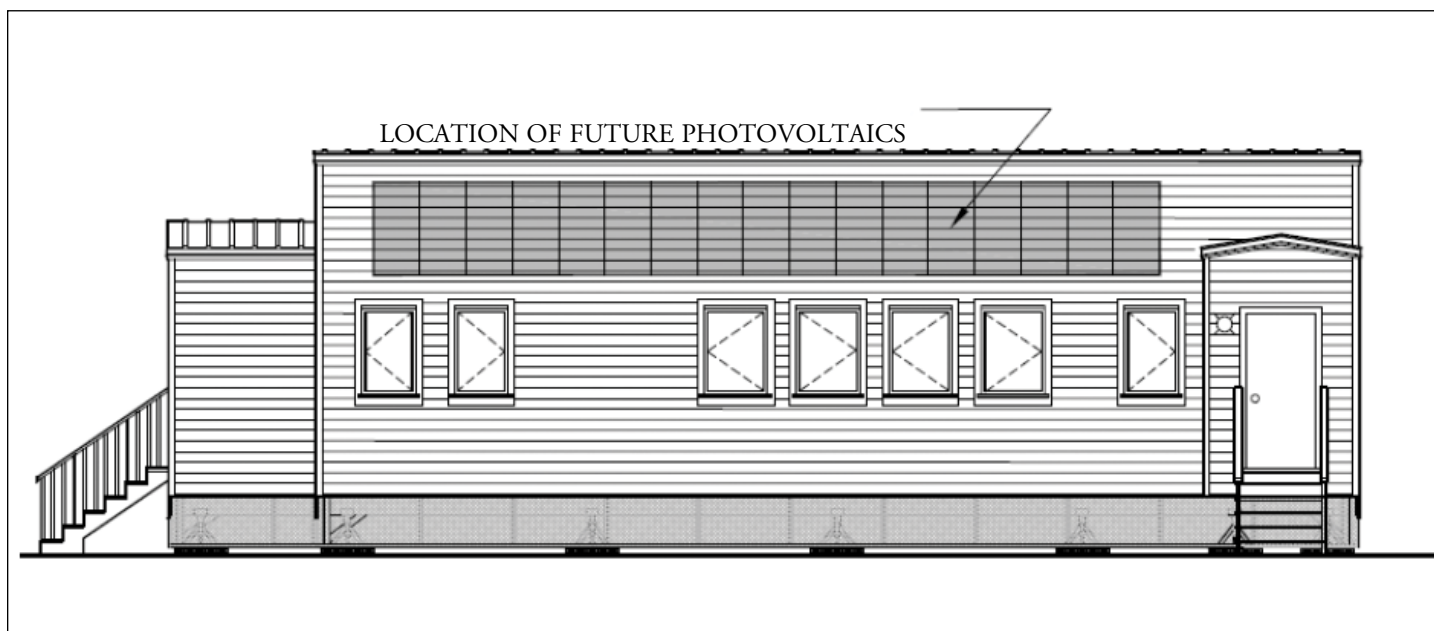


Figure 3 Southeast elevation, Arviat NSH (Credit: NHC)

Building envelope

The Arviat NSH was designed with a highly insulated building envelope:

- Ceiling designed at RSI-11.6 (R-66) nominal rating
- Double-wall assembly achieving RSI-8.0 (R-46) nominal rating
- Windows achieving RSI-0.92 (R-5.2) nominal rating
- Floor above crawl space insulated to RSI-9.1 (R-51.5) nominal rating

The wall assembly of the Arviat NSH is a double-wall system consisting of a 38x140 mm (2x6 in.) exterior wall, a 12-mm (½-in.) air gap, a 38x89 mm (2x4 in.) interior wall, and 38x38 mm (2x2 in.) horizontal strapping with 37.5-mm (1.5-in.) rigid insulation on the interior. Thermal bridges are minimized by staggering the studs of the interior and exterior wall frames and the installation of a layer of interior rigid insulation.

The wall assembly was designed so that the exterior 38x140 mm (2x6 in.) wall and the interior 38x89 mm (2x4 in.) interior wall could be assembled and then tacked in place without touching. Plywood strips were installed to brace and separate the two stud walls. Exterior sheathing was then installed, followed by the roof. The whole envelope was enclosed in Tyvek spun-bonded olefin wrap over the exterior of the wall and roof assemblies as a continuous air barrier system.

The wall was then insulated and the 0.15-mm (6-mil) polyethylene was attached to the inside of the 38x89 mm (2x4 in.) wall as the vapour barrier. The 38x38 mm (2x2 in.) strapping was installed on the interior with 37.5-mm (1.5-in.) rigid insulation and finished with 12 mm (½-in.) drywall. Special attention was paid during construction to ensure the continuity of the air barrier system in the building envelope.

Space heating

The Arviat NSH uses an oil-fired boiler (Energy Star®) with a rated AFUE of 86.5%. It has an input of 112 MBH (32.8 kW) and an output of 98 MBH (28.7 kW). With a Weil Mclean zone controller WMCR-6, the heating system circulates hot water to Slant/Fin model 351-14 hydronic baseboard heaters inside each room. The oil-fired boiler also heats a 151-L (40-U.S.-gallon) indirect domestic hot water tank. The domestic water for the Arviat NSH is supplied by truck service and there is a 1,514-L (400-U.S.-gallon) cold domestic water holding tank in the mechanical room.

Mechanical ventilation

As is standard practice in new housing construction with the NHC, a heat recovery ventilator (HRV) in the house provides efficient and economical, year-round mechanical ventilation, supplies fresh air to all occupied rooms, and exhausts air from the kitchen and bathroom. Given space constraints in the mechanical room of the Arviat NSH, the HRV was installed in the heated ceiling space above the hallway.

ENERGY MODELLING OF DESIGN OPTIONS FOR THE NSH

The Northern Sustainable House initiative set a design objective to achieve a 50% reduction in energy consumption relative to the 1997 Model National Energy Code for Houses. Natural Resources Canada's HOT2000 residential energy consumption simulation tool was used to model the constructed unit. The modelling indicated that the modelled Arviat NSH consumes about 44% less energy than the MNECH baseline house.

In terms of affordability, compared to the MNECH baseline house, the Arviat NSH is projected to consume approximately 70 kWh (\$50) less in electricity and 2,200 Litres (\$2,600) less in oil annually. Table 1 outlines the additional cost of envelope upgrades to the Arviat NSH as compared to typical construction.

As evaluated by HOT2000, the Arviat NSH would achieve an EnerGuide rating of 85. An equivalent house in Arviat built to the standards of MNECH 1997 (baseline house) was also modelled in HOT2000 and achieved an EGH rating of 73. While the modelled results for the Arviat NSH fell just short of the 50% energy reduction goal, the EGH rating puts the Arviat NSH in the same category as some of the most energy-efficient new houses currently on the Canadian market.

Table 1 Additional cost of envelope upgrades of the Arviat NSH, compared to typical NHC construction

	Floor	Wall	Roof
Standard NHC system	305-mm (12-in.) deep joists	38x140 mm (2x6 in.) with RSI-3.9 (R-22) + 38-mm (1.5-in.) semi-rigid insulation	2 layers of RSI-3.9 (R-22) batt + 38 mm (1.5-in.) semi-rigid insulation
Arviat NSH system	No changes	Add interior 38x89 mm (2x4 in.) with RSI-2.8 (R-16) batt insulation	Deeper joist + 1 more batt of RSI-3.9 (R-22), no rigid insulation
Additional material cost	N/A	\$2,300	\$3,140
Additional labour cost	N/A	\$4,700	\$500
Total additional cost		\$7,000	\$3,640

IMPLICATIONS FOR THE NORTHERN HOUSING INDUSTRY

This project demonstrates that sustainable housing technologies and practices can be successfully deployed within the very challenging context of northern housing. In this respect, integrated design charrettes have a role to play in transforming local industry and consumer attitudes, awareness and knowledge regarding higher performance housing. Active engagement of all stakeholders from planning through to the commissioning can help innovative housing projects meet their objectives. The project also demonstrated the importance of quality assurance protocols to help ensure materials and systems are installed as planned and performed as expected. Finally, the project shows how innovative technologies and practices can be applied to housing projects in the Far North and the challenges associated with the deployment and maintenance of such systems.

Research Highlight

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Housing Research at CMHC

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