RESEARCH HIGHLIGHT

Documentation of Super-Insulated Housing in Yukon

March 2017 Technical Series

INTRODUCTION

Since 2007, Yukon Housing Corporation (YHC) has built 224 super-insulated public housing units, with approximately 300 market units built across the territory by the private sector. However, there has been little to no follow-up on the performance of these houses.

Anecdotal information suggested that these houses were neither difficult nor expensive to build but have far superior energy efficiency and comfort compared to standard construction. This study was undertaken to document the design and construction of super-insulated (SuperGreen™[1]) housing within Yukon and provide information on their performance, their return on investment (where possible) and the lessons learned by builder participants.

Figure 1 Structurally insulated panel SuperGreen™ home

METHODOLOGY

Builder and project identification

Canada Mortgage and Housing Corporation (CMHC) provided funding to the Yukon Government's Energy Solutions Centre (ESC) (YG's Energy Branch) to compile a list of homebuilders having constructed super-insulated houses that qualify as SuperGreen™ or meet a minimum EnerGuide™ rating of 85. Yukon Housing Corporation was consulted to help identify qualified homebuilders within the territory, while ESC consulted with territorial and regional homebuilder associations; water, fuel and electricity utilities; and local housing authorities to identify any other appropriate homebuilders.

Information gathering and phone survey

Based on the suggested list of builders and projects, ESC contacted the identified homebuilders to solicit participants for this project and schedule interviews. Participants also provided written permission for ESC to collect technical information on home construction, including data on energy performance, construction approaches, sustainable practices and technologies used, project size (number of storeys and heated floor area), tenure (ownership and rental), geographical location and likelihood of accessible information.

[1] SuperGreen™ represents a Yukon Housing Corporation standard for residential construction that requires buildings to meet an EnerGuide rating of 85 or better.

Homeowners (or occupants) of identified units were also contacted to collect information on their experience with super-insulated housing through an interview. Written permission was also sought to have a home audit completed by a registered energy advisor to establish an EnerGuide rating. This permission included the photographing of the exterior and key sustainable features.

Case study candidates were prioritized based on the completeness of the information on the home and the willingness of both the homebuilder and the homeowner/occupant to participate in the study. A prioritized list of 10 case studies was approved by ESC and CMHC.

Interview

Through the interview process, ESC solicited (or arranged to solicit) information on super-insulated design and construction details from the builders. This included as-built plans; specifications for the structure, envelope, space heating, domestic hot water, ventilation, lighting and appliances; modelling results; EnerGuide for Home (EGH) rating results; construction documents such as inspection reports and photographs; and airtightness testing results.

ESC also recorded available cost information, builder perceptions on the design and construction of super-insulated houses (lessons learned and knowledge gained, homeowner contact information and potential leads on other super-insulated projects that might be considered for inclusion in the study).

Site visits

ESC coordinated with a photographer and a Natural Resources Canada (NRCan) listed energy advisor to undertake a site visit for additional data collection.

Reporting

Each case study includes (where available):

- an overview of the construction of the house (type, number of storeys, heated floor area, structure, envelope, space heating, domestic hot water, ventilation, lighting, appliances, renewable energy systems and water systems);
- energy efficiency features;
- renewable energy features;
- indoor environment features;
- environmental/resource conservation features;
- affordability considerations (for example, construction costs and operating costs);
- lessons learned;
- a technical summary;
- the project team;
- photographs of key features; and
- EnerGuide Rating System rating information, airtightness testing results and utility bills.

Figure 2 SuperGreen™ triplex with solar panels

Figure 3 Larsen truss wall system construction

FINDINGS

In most cases, the super-insulated houses were built by builders for the primary residents who wanted to reduce operating and maintenance costs through increased energy efficiency. These builders either had previous experience building high-efficiency, single-family homes in the North or, after learning of Yukon's SuperGreen™ energy standard, requested and received technical support from YHC and ESC to build their homes. All houses achieved an as-designed EnerGuide rating between 85 and 87, with one achieving a 90 thanks to the inclusion of solar photovoltaic (PV) technology. Air change rates ranged from 1.3 to 0.4 ACH, and projected energy use ranged from 73 kWh/m^2 to 208 kWh/m^2. Houses were typically two-storey, detached units ranging in size from 89 m^2 (960 sq. ft.) (duplex unit) to 427 m^2 (4,600 sq. ft.) with either a finished basement, a crawl space or a slab-on-grade foundation. Two houses utilized timber-frame construction, while another was constructed from structural insulated panels (SIPs).

Most of the designs focused on deep wall construction—including a double wall or Larsen truss wall system, and insulation choices included spray foam, mineral wool, expanded polystyrene (EPS) foam billets or fibreglass batt, with R-values ranging from R-36 to R-56.

Window selection was evenly split between triple-glazed and quadruple-glazed, argon-filled, low-e windows with insulated vinyl frames. Ceiling insulation values ranged from R-52 to R-100, while foundation slab values ranged from R-21 to R-40.

Electric baseboard heating was used in almost every case, as it is considered inexpensive to install and cost-effective. Also, simple electric baseboard heaters have much-reduced regular maintenance and servicing costs, as compared to furnaces and boilers. Some builders also opted for propane fireplaces or wood stoves for ambiance and backup. One house utilized a cold-climate heat pump, while another chose a high-efficiency propane combination system for space and domestic water heating with in-floor radiant heat. One house was constructed with solar PV panels, while two others were designed to be solar-ready.

Figure 4 Roof framing

Figure 5 Heat recovery ventilator (HRV), hot water and drainwater heat recovery system

LESSONS LEARNED

With the exception of one modular system, the houses were built on site as one-off designs. Accordingly, they took longer to build and cost more than conventionally built tract houses, but the modestly higher costs of wall construction were at least partially offset by the reduced size and complexity of the mechanical system.

While different approaches were used for achieving an EGH rating of 85 or higher, these houses perform as a package that includes increased R-values in the walls, floor and ceiling; triple- or quadruple-glazed windows; and optimized space heating and ventilation systems that work together under harsh conditions.

Extra time may be needed for constructing additional wall framing; however, it provides a tight, durable and energy-efficient house. In some cases, additional time was required as this was the first time the builders were trying out new construction techniques or systems.

Local contractors, builders and inspectors may not be versed in certain technologies, which may add to construction timelines. It is important to ensure that all trades and subtrades are on board and that good communication exists so that everyone understands the process.

Quadruple-pane windows can be heavy to install, but the additional reduction of noise from the outside that they provided was seen as a valuable investment in noisier locations. Insulated concrete forms (ICFs) were considered a better option than preserved wood foundations but were often not chosen as they were too costly for the budget. Double door combinations must be designed so as to permit adequate ventilation for pressure relief.

It is recommended that design plans be run through the NRCan EGH rating system early in the process, in order to better understand optimal pathways to achieving energy efficiency goals.

Most of the homebuilders believe that the long-term savings of a SuperGreen™ home can offset the initial incremental cost of construction; however, the higher upfront cost can be a mortgage limitation for people who might be considering SuperGreen™. Lots of contractors know how to achieve higher Rvalues but felt that clients tend to want to keep the initial cost as low as possible. To address this issue, a rebate of up to $10,000 has recently been introduced and is available through the ESC Good Energy rebate program.

Figure 6 SuperGreen™ home with rental suite

Table 1 Summary of Case Studies

Case study	1	2	3	4	5	6	7	8	9	10
Floor area	357m² 3,846 ft²	427 m² 4,600 ft²	112 m² 1,200 ft²	167 m² 1,800 ft² + 48 m² 520 ft²	223 m² 2,400 ft²	204 m² 2,195 ft² + 80.4 m² 865 ft²	214 m² 2,300 ft²	89 m² 960 ft² each unit	130 m² 1,400 ft² each unit	183 m² 1,974 ft² Total liveable area
Dwelling type	2 storey detached	2 storey detached	2 storey detached	2 storey + loft	Detached bungalow	2 storey detached + suite	2 storey detached	2 storey duplex	2 storey triplex	Triplex – 2 single storey and 1- 2 storey
Basement type	Finished basement	Finished basement	Heated crawlspace	Slab on grade	Finished basement	Partially Finished	Crawlspace	Unfinished basement	Crawlspace	Slab on grade
Attached garage	heated	heated	no	heated	no	no	no	no	no	no
Wall	R36	R40	R44		R36	R43	R51.5	R52	R56	
Ceiling	R65	R70	R54	R80	R70	R70	R52	R100	R80	R100
Foundation walls	R21	R38	R40					R39		R20
Windows (Ar filled, low-e)	Triple Glazed	Triple Glazed	Quad Glazed, special insulated frames	Quad Glazed	Triple Glazed	Triple Glazed	Quad Glazed	Triple Glazed	Quad Glazed	Quad Glazed, (not on South side)
Space heating system	Cold climate heat pump e coil on furnace fan as backup	High efficiency propane combo system for space and DHW Infloor radiant	Electric baseboard, with wood backup	Electric baseboard, propane fireplace (solar ready)	Electric baseboard	Electric baseboard	Wood with electric baseboard as back-up	Electric baseboard, in slab radiant heat in basement for thermal storage (solar ready chases)	Electric baseboard	Electric baseboard (solar PV)
EnerGuide rating	87	86	85	87	85	85	85	87	87	86 no solar 90 solar
ACH50	1.3 ach	0.4 ach	0.9 ach	0.4 ach	0.56 ach	0.7 ach	1 ach	0.62 ach	1.1 ach	0.8 ach
Equivalent leakage area @-10Pa	405 cm² 62.7 in²	131 cm² 20 in²	128 cm² 19.76 in²	65.8 cm² 10.2 in²	125 cm² 19.4 in²	216 cm² 33.5 in²	277 cm² 43 in²	59 cm² 9.2 in²	136.1 cm² 21.1 in²	141 cm² 21.9 in²
Projected energy consumption	23,636 kWh/yr	31,314 ekWh/yr*	19,714 kWh/yr	20,656 kWh/yr	24,460 kWh/yr	29,423 kWh/yr	25,936 kWh/yr	16,644 kWh/yr	17,726 kWh/yr	19,604 kWh/yr
Space heating energy input	28GJ 7735kWh	67GJ 18,647 kWh	18GJ 5087 kWh	21GJ 5938 kWh	35GJ 9632 kWh	58GJ 16,142 kWh	40GJ 11,051 kWh	6GJ 1793 kWh	9GJ 2592 kWh	12GJ 3373 kWh
Design heat loss	14 kW	17 kW	6 kW	7.5 kW	8.5 kW	15.5 kW	10.5 kW	4.5 kW	5.5 kW	6.5 kW

*ekWh is equivalent kWh determined by showing the energy content of the fuel plus electrical energy.

CONCLUSIONS

The design and construction of super-insulated, properly ventilated, energy-efficient housing can provide greater comfort and indoor air quality, reduce greenhouse gas emissions, prevent moisture and mould problems and, of course, lower the heating bills. These case studies present a number of approaches to achieving energy-efficient housing that are neither onerously expensive nor difficult to build. As with all new approaches, planning is essential and Yukon Housing Corporation and the Energy Solutions Centre can provide technical information and assistance to builders considering SuperGreen™ construction.

IMPLICATIONS FOR THE HOUSING INDUSTRY

As noted with these case studies, one-off designs can be more costly to build than tract built housing due to economies of scale. Newer technologies may require additional training time as well, leading to increased costs – which should ultimately be reduced as SuperGreen™ construction practices become commonplace. Even so, lower income households and affordable housing providers may be financially limited to incorporation of certain strategies and technologies as they balance initial capital outlay with reduced operational costs. Potential solutions to this can include innovative energy efficiency financing options (loans, tax exemptions, etc.) as well as broader support to the construction industry with education and training in innovative construction techniques. While these case studies showcase examples from the Yukon, they highlight opportunities for energy efficient construction across the North. Further research is needed to assess the state of, and document, energy efficient construction examples in NWT, Nunavut, Nunavik and Nunatsiavut.

Full Report

Final Research Report (PDF): Document of Super-Insulated Housing in Yukon: ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Research_Reports-Rapports_de_recherche/eng_bilingual/RR_Super_Green_Housing_Yukon_EN_Feb3.pdf

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Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This Research Highlight is one of a series intended to inform you of the nature and scope of CMHC's research.

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