Research & Development Highlights

Socio-economic Series *Issue 15*

Sustainable Residential Developments: Planning, Design and Construction Principles (Greening the "Grow Home")

Introduction

Increased environmental awareness and socio-economic changes in Canada are creating a demand for houses that are more affordable, more energy- and resource-efficient, and more responsive to changing demographics. In 1990, McGill University's Affordable Homes Program unveiled the "Grow Home," an adaptable narrow-front town house that is responding to these new demands. Just under 5 metres wide, the Grow Home substantially reduces land and infrastructure costs, compared to conventional detached houses, Its smaller size (93 m^2) and shared walls also reduce construction and operating costs. Without compromising high-quality construction and materials, Grow Homes call be built for under $40,000, and, depending on tile price of land and servicing costs, they can be sold for under $100,000 overall.

This study, commissioned by Canada Mortgage and Housing Corporation (CMHC), investigates a range of issues related to planning, designing and constructing more sustainable housing. Using a standard Grow Home as the base case, the report reviews the following products, methods and practices with the potential to conserve energy, land, water and other natural resources:

1. Unit Planning Principles
2. R-2000 Building Technology
3. Construction Details
4. Prefabricated Wall Panels

Cette publication est aussi disponible en français sous le titre *Aménagements domicilaires durables—Principes de conception et de construction(La maison évolutive, version écologique)*

5. Building Materials
6. Window Units
7. Mechanical Systems
8. Water-Efficient Plumbing Fixtures
9. Xeriscapes: Water-Efficient Landscapes
10. Waste Disposal
11. Healthy Indoor Environments

Where applicable, the above products, methods and practices are analyzed in terms of their payback periods: the length of time necessary to recover an initial investment (in this case, the price differential between standard technologies and their more resource-efficient counterparts). Each chapter concludes with general guidelines builders can follow to improve the resource-efficiency of their houses. Additional sources of information for each of the subject areas are also provided.

Some Key Findings

Unit Planning Principles

> **One of the easiest ways of reducing material use and heat loss isby simplifying a unit's configuration.**

One of the easiest ways of reducing material use and heat loss is by simplifying a unit's configuration. A circular configuration is the most efficient form, in terms of materials and heating requirements. However, it is difficult to partition interior spaces, the curved walls can be expensive to build, and the form does not meet housing expectations of Canadians. While somewhat less efficient, square and rectangular configurations represent more traditional and marketable house forms. Moreover, the land and infrastructure savings associated with rectangular configurations, which can be built on narrower lots, may more than offset the energy and material savings associated with simpler, circular plans. Rectangular units are also easily attached as row-houses, which leads to further material and energy savings.

Material requirements can be further reduced through more efficient framing practices. For example, lumber used for wall framing can be reduced by 12 percent by spacing studs at 610 mm, rather than 405 mm. Aligning tloor joists with wall studs eliminates 61 metres of wall studs. Using two studs in corners, rather than three, saves an additional 19.5 metres of lumber, and the same technique applied to interior partitions saves 97.5 metres of interior framing lumber. With every four houses built, these techniques can save enough lumber to frame the walls of a fifth house.

Wood waste can be reduced by ensuring that floor plans accommodate standard modular dimensions of building materials. Table I illustrates four simple plans with the same tloor areas, but different dimensions. Although there is no significant difference in the amount of wood required to build each of these plans, the amount of waste generated varies significantly.

Table I Alternative Modular Design / Dimensions and Material Usage

			Joists		Sheathing	
Plan	Module	Dimensions (m^2)	Ordered (m)	Wasted (m)	Ordered (m^2)	Wasted (m^2)
Plan 1	No module	*5.2 x 9 m (46.8 in2)*	[illegible]	[illegible]	[illegible]	[illegible]
Plan 2	406 mm (16")	5.3 x 8.7 in (46.1 in2)	408.4	24.0	249.7	16.4
Plan 3	610 mm (24')	4.3 x 11 m (47.3 in2)	302.4	2.4	249.7	7.3
Plan 4	1220 mm (48')	4.9 x 9.6 m (47.04 in2)	302.4	0.0	237.9	0.0

Construction Details

Simple measures can help save energy and improve indoor air quality. Air leakage rates in an average home range from 0.5 to 1.0 air changes per hour (ACH). Filling in spaces between joists with batt or rigid board insulation, increasing stud spacing to reduce thermal bridging, properly sealing service penetrations, and ensuring air-tight window and door installation can reduce air leakage to 0.1, or even 0.05 ACH. For a 150 m^2 house, this represents a reduction of about 348 m^3 of air. The cost of heating and conditioning this air in Montreal is about *$455* a year. Table 2 illustrates that the additional costs for air-tight construction are paid back in energy savings within three to five years.

Table 2 Cost Implications of Air-Tight Construction

DETAILING QUALITY	ENERGY SAVINGS	INCREMENTAL CONSTRUCTION COSTS	PAYBACK PERIOD (YEARS) [1]
Air-tight (0.10 ACH)	$77	$230	3.3
Very air-tight (0.05 ACH)	$88	$381	5.1

[1] True payback period; based on discount rate of 10% and 4% escalation in energy costs

Prefabricated Wall Panels

The use of prefabricated panel systems can lead to substantial savings in both construction and operating costs. Operating costs are reduced by virtue of the systems~ superior quality: improved thermal resistance, reduced thermal bridging and air-tight construction. Construction costs can be lowered by reducing material wastage on site (e.g. warpage, rot, theft, vandalism). The faster assembly process can also translate into savings in overhead and financing costs.

Windows

Selecting more energy-efficient windows can significantly reduce heat loss through the building envelope. The savings are most pronounced in row-houses, as the window area accounts for a greater portion of the exterior wall area. In a row-house version of the Grow Home, windows occupy some 25 percent of the total exposed wall area, and account for 45 percent of the total heat loss. Table 3 shows the energy-cost savings and payback periods associated with different window glazings. The energy-cost savings are based on heat losses only, and do not include passive solar gains. Accounting for solar heat gains, an upgrade from a standard window unit to a high-performance unit (RSI 0.59) can pay for itself in 3.5 years.

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Table 3 Payback Period for Different Glazing Types

GLAZING TYPE	RSI (WINDOW UNIT)	HEAT LOSS (W)	ENERGY CONSUMED (KWh)	ENERGY COST SAVINGS	INCREMENTAL COST INCREASE	PAYBACK PERIOD (YEARS)
alum, spacer	0.36	1780	2599	Standard	Standard	—
+ low-e coating	0.47	1363	1991	$29	$239	11.7
+ argon gas	0.52	1232	1799	$37	$259	9.3
+ insulative spacer	0.59	1093	1597	$47	$408	12.6

Window frame assumed to be wood
R51 values and incremental costs from Scanada, 1992
Energy consumption is for the Montreal area; heating costs assumed at *$0.O469IKWh*
. Paybaclc based on heat loss only; heat gains not accounted for

Water Efficiency:

Table 4 shows that installing a complete water-efficient package will cost an additional $74. The payback period for these upgrades is eight months, based on the average Canadian water rate of $0.65/in3. This payback period does not account for the additional energy savings that accrue from conserving hot water.

Table 4 Water-Efficient Fixtures and Payback Periods

FIXTURE	CONVENTIONAL CONSUMPTION	WATER-SAVING DEVICE	WATER SAVINGS PER UNIT	WATER SAVINGS L/DAY/ CAPITA	INITIAL COST DIFFERENCE	PAYBACK PERIOD (MONTHS)
Toilet	2OLJftush	low-tlow toilet GLIflush	14L/ flush	70	$60 (for 2 toilets)	15
Shower	2OLImin.	low-flow showerhead 9.SLImin.	10.5L/ mm.	63	$5 (for 1 showerhead)	1
Kitchen Faucet	13.SLIinin.	Aerator 7.5L'min.	6L/mmn.	4	$3 (for 1 kitchen aerator)	13
Bathroom Faucet	13.51mm.	Aerator 2LImin.	11.5L/ mm.	23	$6 (for 2 bathroom aerators)	5
COMPLETE WATER-EFFICIENT PACKAGE					$74	8

The second and third parts of this study examine general planning principles that affect the overall liveability of Grow Home housing environments. Issues related to site planning, housing identity, outdoor living spaces, vehicular circulation and parking, and environmental comfort are explored. The tradeoffs and costs associated with alternative community designs are illustrated using three hypothetical developments of varying densities and housing types for an existing site in Aylmer. Quebec. The densest of these three scenarios, at 63 units per net hectare, was the most affordable development on a per unit basis, in terms of land costs, construction costs, infrastructure costs and green space costs.

This issue of *Research aiid Development Highlights* has been produced as a result of work carried out by the Research Division of Canada Mortgage and Housing Corporation (CMHC). Any questions about the contents of this highlight may be directed to Mr. David D'Amour, Researcher. Urban and Environmental Relations, at (613) 748-2325.

The Policy, Research and Communications Sector of CMHC carries out and finances a broad range of research on the social, economic and technical aspects of housing. This CMHC *ReseaK'h and Developnwnt Highlight* is one of a series intended to inform you briefly of the nature and scope of these activities.

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